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SINAMICS S120

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SINAMICS S120

Function Manual

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Valid for

Drive
SINAMICS S120

Firmware release
2.4

03/2006 Edition

Safety information/instructions

This manual contains information which you should carefully observe to ensure your own personal safety and to prevent material damage. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring to property damage only, have no safety alert symbol. The warnings appear in decreasing order of risk as given below:



Danger

indicates that death or severe personal injury **will** result if proper precautions are not taken.



Warning

indicates that death or severe personal injury **may** result if proper precautions are not taken.



Caution

with a warning triangle indicates that minor personal injury can result if proper precautions are not taken.

Caution

without a warning triangle means that material damage can occur if the appropriate precautions are not taken.

Notice

indicates that an unwanted result or situation can result if the appropriate advice is not taken into account.

If several hazards of different degrees occur, the hazard with the highest degree must always be given priority. If a warning note with a warning triangle warns of personal injury, the same warning note can also contain a warning of material damage.

Qualified personnel

The associated device/system may only be set up and operated using this documentation. Commissioning and operation of a device/system may only be performed by **qualified personnel**. Qualified persons are defined as persons who are authorized to commission, to ground, and to tag circuits, equipment, and systems in accordance with established safety practices and standards.

Correct usage

Please note the following:



Warning

The device may be used only for the applications described in the catalog and in the technical description, and only in combination with the equipment, components and devices of other manufacturers where recommended or permitted by Siemens.

Correct transport, storage, installation and assembly, as well as careful operation and maintenance, are required to ensure that the product operates safely and without faults.

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Exclusion of liability

We have checked the contents of this manual for agreement with the hardware and software described. Since deviations cannot be precluded entirely, we cannot guarantee full agreement. The information given in this publication is reviewed at regular intervals and any corrections that might be necessary are made in the subsequent editions.

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Foreword

Information on the SINAMICS S120 documentation

The SINAMICS S120 documentation is divided into the following areas:

- General documentation/catalogs
- Manufacturer/service documentation

A current overview of the documentation in the available languages is provided in the Internet:

<http://www.siemens.com/motioncontrol>

Follow menu items – “Support” –> “Technical Documentation” –> “Overview of Publications”.

The Internet edition of DOConCD, DOConWEB, are available in the Internet:

<http://www.automation.siemens.com/doconweb>

Information on the range of training courses and FAQs (Frequently Asked Questions) are available in the Internet:

<http://www.siemens.com/motioncontrol>

Follow the menu item “Support”.

Useful phases and their documents/tools (examples)

Table F-1 Useful phases and available documentation/tools

Useful phase	Document/tool
Orientation	SINAMICS S120 sales documentation
Planning/engineering	SIZER engineering tool Configuration Manuals, Motors
Select/order	SINAMICS S120 Catalogs
Configuring/installation	SINAMICS S120 Equipment Manuals <ul style="list-style-type: none">• SINAMICS S120 Equipment Manual Control Units and Supplementary System Components• SINAMICS S120 Equipment Manual Booksize Power Sections• SINAMICS S120 Equipment Manual Chassis Power Sections• SINAMICS S120 Equipment Manual AC DRIVE

Table F-1 Useful phases and available documentation/tools, continued

Useful phase	Document/tool
Commissioning	<ul style="list-style-type: none"> • STARTER Parameterization and Commissioning tool • SINAMICS S120 Getting Started • SINAMICS S120 Commissioning Manual • SINAMICS S120 Commissioning Manual CANopen • SINAMICS S120 Function Manual • SINAMICS S List Manual
Usage/operation	<ul style="list-style-type: none"> • SINAMICS S120 Commissioning Manual • SINAMICS S List Manual • SINAMICS S150 Operating Instructions
Maintenance/servicing	<ul style="list-style-type: none"> • SINAMICS S120 Commissioning Manual • SINAMICS S List Manual • SINAMICS S150 Operating Instructions

Audience

This documentation is intended for machine manufacturers, commissioning engineers, and service personnel who use the SINAMICS S drive system.

Objective

The Function Manual describes all the procedures and operational instructions required for commissioning and servicing SINAMICS S120.

The Function Manual is structured as follows:

- Chapter 1 Infeed
- Chapter 2 Extended Setpoint Channel
- Chapter 3 Operating Modes
- Chapter 4 Extended Functions
- Chapter 5 Basic Information About the Drive System

Entry level personnel are advised to first read the Chapter Basic Information.

Finding your way around

The following guides are provided to help you locate information in this manual:

1. Table of Contents
2. List of Abbreviations
3. References
4. Index

Standard scope

The scope of the functions described in this document can deviate from the scope of functions of the supplied drive system.

- Other functions not described in this documentation might be able to be executed in the drive system. However, no claim can be made regarding the availability of these functions when the equipment is first supplied or in the event of servicing.
- Functions can be described in the documentation that are not available in a particular product version of the drive. The functions of the supplied drive system should only be taken from the ordering documentation.
- Extensions or changes made by the machine tool manufacturer are documented by the machine tool manufacturer.

For reasons of clarity, this documentation does not contain all of the detailed information on all of the product types. This documentation cannot take into consideration every conceivable type of installation, operation and service/maintenance.

Technical support

If you have any further questions, please call our hotline:

European and African time zones

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Internet: <http://www.siemens.de/automation/support-request>

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Asian and Australian time zones

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Note

Country telephone numbers for technical support are provided under the following Internet address:

<http://www.siemens.com/automation/service&support>

Questions on the manual

Please send any questions regarding the technical documentation (e.g., suggestions for improvement, corrections) to the following fax number or e-mail address:

Fax: +49 (0) 9131 / 98 - 63315

E-mail: motioncontrol.docu@siemens.com

Faxformular: refer to the feedback sheet at the end of the documentation

Internet address for SINAMICS

<http://www.siemens.com/sinamics>

EC Declaration of Conformance

The EC Declaration of Conformance regarding the EMC Directives is available as follows:

- Internet
<http://www.ad.siemens.de/csinfo>
Product/Order No.: 15257461
- Siemens regional office
From the responsible regional offices of the A&D MC business division of Siemens AG.

Notation

The following notation and abbreviations are used in this documentation:

Notation for parameters (examples):

- p0918 Adjustable parameter 918
- r1024 Visualization parameter 1024
- p1070[1] Adjustable parameter 1070, index 1
- p2098[1].3 Adjustable parameter 2098, Index 1 Bit 3
- p0099[0...3] Adjustable parameter 99, indices 0 to 3
- r0945[2](3) Visualization parameter 945, index 2 of drive object 3
- p0795.4 Adjustable parameter 795, bit 4

Notation for faults and alarms (examples):

- F1234 Fault 1234
- A5678 Alarm 5678

General notation:

- The sign “≐” means “is equal to”

ESD information



Caution

An **electrostatic-sensitive device** (ESD) is an individual component, integrated circuit, or module that can be damaged by electrostatic fields or discharges.

Regulations for handling ESD components:

- When handling components, make sure that personnel, workplaces, and packaging are well grounded!
 - Personnel in ESD areas with conductive flooring may only handle electronic components if:
 - They are grounded with an ESD wrist band
 - They are wearing ESD shoes or ESD shoe grounding straps
 - Electronic boards should only be touched if absolutely necessary. They must only be handled on the front panel or, in the case of printed circuit boards, at the edge.
 - Electronic boards must not come into contact with plastics or items of clothing containing synthetic fibers.
 - Boards must only be placed on conductive surfaces (work surfaces with ESD surface, conductive ESD foam, ESD packing bag, ESD transport container).
 - Electronic modules must be kept at a distance from data display equipment, monitors, and televisions (minimum distance from screen: >10 cm).
 - Measurements must only be taken on boards when:
 - The measuring device is grounded (with a protective conductor, for example).
 - The measuring head has been temporarily discharged before measurements are taken on a floating measuring device (e.g. touching a bare metal controller housing).
-

Safety-related guidelines



Danger

- Commissioning shall not start until you have ensured that the machine in which the components described here are to be installed complies with Directive 98/37/EC.
 - SINAMICS devices and AC motors must only be commissioned by suitably qualified personnel.
 - The personnel must take into account the information provided in the technical customer documentation for the product, and be familiar with and observe the specified danger and warning notices.
 - When electrical equipment and motors are operated, the electrical circuits automatically conduct a dangerous voltage.
 - Dangerous mechanical movements may occur in the system during operation.
 - All work on the electrical system must be carried out when the system has been disconnected from the power supply.
 - SINAMICS devices with AC motors must only be connected to the power supply via an AC-DC residual-current-operated device with selective switching once verification has been provided that the SINAMICS device is compatible with the residual-current-operated device in accordance with EN 50178, Subsection 5.2.11.2.
-



Warning

- The successful and safe operation of these devices and motors depends on correct transport, proper storage and installation, as well as careful operation and maintenance.
 - The specifications in the catalogs and offers also apply to special variants of the devices and motors.
 - In addition to the danger and warning information provided in the technical customer documentation, the applicable national, local, and system-specific regulations and requirements must be taken into account.
 - Only protective extra-low voltages (PELVs) that comply with EN60204-1 must be connected to all connections and terminals between 0 and 48 V.
-



Caution

- The surface temperature of the motors can reach over +80 °C.
 - For this reason, temperature-sensitive parts (lines or electronic components, for example) must not be placed on or attached to the motor.
 - When attaching the connecting cables, you must ensure that:
 - They are not damaged
 - They are not under tension
 - They cannot come into contact with rotating parts.
-

Caution

- As part of routine tests, SINAMICS devices with AC motors undergo a voltage test in accordance with EN 50178. Before the voltage test is performed on the electrical equipment of industrial machines to EN 60204-1, Section 19.4, all connectors of SINAMICS equipment must be disconnected/unplugged to prevent the equipment from being damaged.
 - Motors must be connected in accordance with the circuit diagram provided, otherwise they could be destroyed.
-

Note

- When operated in dry operating areas, SINAMICS equipment with three-phase motors conforms to low-voltage Directive 73/23/EEC.
-



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Infeed

1

1.1 Active Infeed

1.1.1 Active Infeed closed-loop control

Features

- Controlled DC link voltage whose level can be adjusted
- Regenerative feedback capability
- Specific reactive current setting
- Low line harmonics, sinusoidal line current

Description

Active Infeed closed-loop control works together with the line reactor and the Active Line Module as a step-up converter. The DC voltage level can be defined via parameters.

The open and closed-loop control firmware for the Active Line Module runs on the Control Unit assigned to it. The Active Line Module and Control Unit communicate via DRIVE-CLiQ.

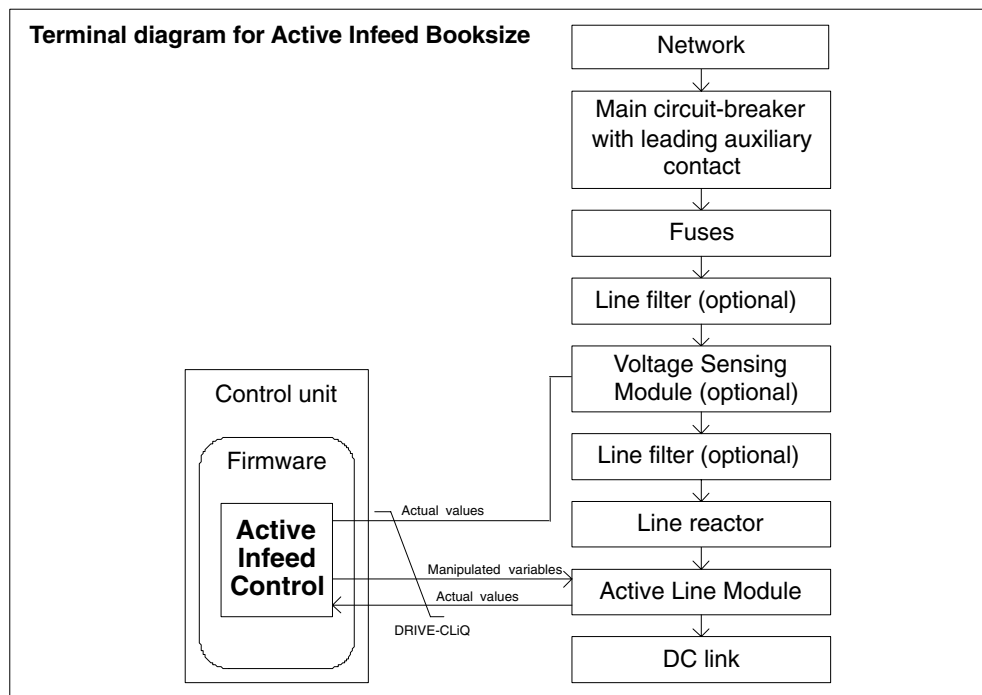


Fig. 1-1 Schematic structure of Active Infeed Booksize

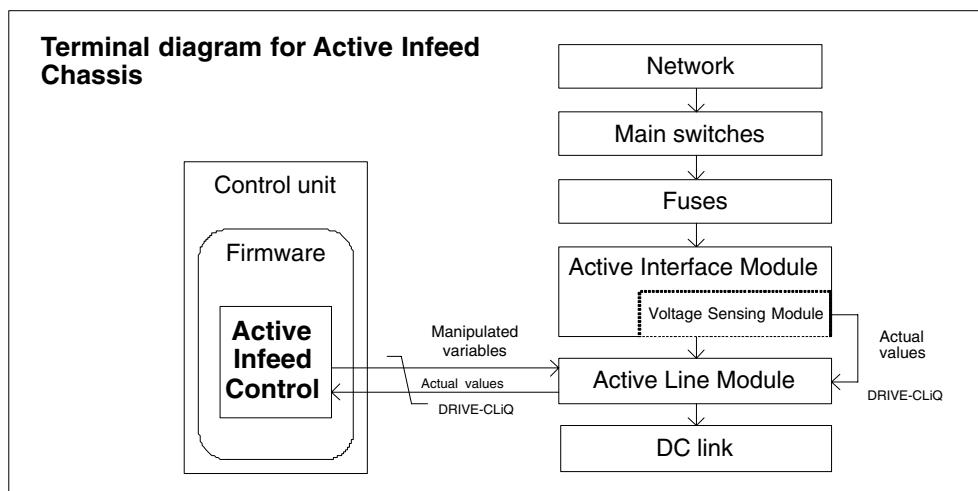


Fig. 1-2 Schematic structure of Active Infeed Chassis

Operating modes of Active Infeed closed-loop control for Active Line Modules Booksize

The Active Line Module can be operated in two different modes depending on the parameterized line supply voltage (p0210):

- Active Mode
In Active Mode, the DC link voltage is regulated to a variable setpoint (p3510), which results in a sinusoidal line current ($\cos\varphi = 1$).
- Smart Mode
In Smart Mode, the DC link voltage is not regulated but is, instead, derived from the rectified line supply voltage. The current waveform in the direction of incoming supply is the same as that of a B6 diode converter. A square-line current occurs in the direction of regenerative feedback.

The DC link voltage setpoint (p3510) and the control type are preset as follows during commissioning in line with the connection voltage (p0210):

Table 1-1 Presetting the control type and DC link voltage booksize

Supply voltage p0210 [V]	380– 400	401– 415	416– 440	460	480
Control type p3400.0	"0" = Active Mode		"1" = Smart Mode		
Vdc_setp p3510 [V]	600	625	562– 594 ¹⁾	621 ¹⁾	648 ¹⁾

1) Voltages specified for Smart Mode are derived from the rectified line supply voltage. The DC link voltage setpoint (p3510) has no effect in this control mode.

Operating modes of Active Infeed closed-loop control for Active Line Modules Chassis

Active Line Modules Chassis only function in Active Mode.

The DC link voltage setpoint (p3510) is preset in line with the supply voltage (p0210) according to the following formula: $p3510 = 1.5 * p0210$.

Commissioning

During commissioning, the device supply voltage (p0210) and the rated line frequency (p0211) must be parameterized. In addition, an optional line filter (p0220) must be selected.

Note

In a supply system without regenerative feedback capability (e.g. generators), regenerative operation must be inhibited via the binector input p3533.

The DC link voltage (p3510) can be set within the following limits:

- Booksize
 - Upper limit: Maximum DC link voltage (p0280)
 - Lower limit: Supply voltage (p0210) multiplied by 1.42
- Chassis
 - Upper limit: Maximum DC link voltage (p0280)
 - Lower limit: Supply voltage (p0210) multiplied by 1.42

Note

If automatic commissioning was carried out with STARTER, the line filter (if used) must be included in the configuration.

Function diagram for Active Infeed (see List Manual)

- 1774 Overviews – Active Infeed
- 8920 Control word sequential control infeed
- ...
- 8964 Messages and monitoring, supply frequency and Vdc monitoring

Key parameters for Active Infeed (see List Manual)

- r0002 Infeed/operating display
- r0046 CO/BO: Infeed missing enable signals
- p0210 Device supply voltage
- p0211 Rated line frequency
- p0220 Infeed line filter type
- p0280 DC link voltage maximum steady-state
- p0840 BI: ON/OFF1
- p0844 BI: 1st OFF2
- p0852 BI: Enable operation
- p0898 CO/BO: Control word sequential control infeed
- p0899 CO/BO: Status word sequential control infeed
- p2138 CO/BO: Control word, faults/alarms
- p2139 CO/BO: Status word, faults/alarms 1
- p3400 Infeed configuration word
- r3405 CO/BO: Status word infeed
- p3410 Infeed configuration word
- p3510 Infeed DC link voltage setpoint
- p3533 BI: Infeed, inhibit regenerative operation
- p3610 Infeed reactive current fixed setpoint
- p3611 CI: Infeed reactive current supplementary setpoint

1.1.2 Line and DC link identification

The characteristic line supply and DC link quantities are determined using the automatic parameter identification routine. They provide the basis to optimally set the controllers in the Line Module.

Note

If the line supply environment changes, or the components connected to the DC link (e.g. after installing and mounting the equipment at the customer's site or after expanding the drive group), then the line supply/DC link identification routine should be repeated with p3410 = 5. Only then can it be guaranteed that the infeed operates with the optimum controller settings.

When the identification function is activated, alarm A06400 is output.

Identification methods

For additional identification methods, see the List Manual.

- p3410 = 4: An identification run for the total inductance and DC link capacitance is initiated when the pulses are next enabled (two measuring routines with different current magnitudes). Data determined during identification (r3411 and r3412) is entered into p3421 and p3422 and the controller is recalculated. At the same time, the parameters for current controller adaptation are device (p6320, p6322). All of the parameters for the infeed module are then automatically stored in a non-volatile memory.
The infeed continues to operate without any interruption with the new controller parameters.
- p3410 = 5: The same measurements and write operations are always carried-out for p3410 = 4. However, before the first identification run, the parameter values for line inductance and DC link capacitance are reset (p3421 = p0223 and p3422 = p0227) and the coarse settings are made for the controller.
p3410 is automatically set to 0 after an identification run has been successfully completed.

Note:

The identification using p3410 = 5 is the preferred method.

Closed-loop control may, for example, have to be reset to the factory setting if the identification process is unsuccessful.

Parameter overview (see List Manual)

- p3410 Infeed identification method
- p3421 Infeed inductance
- p3422 Infeed DC link capacity
- p3620 Infeed current controller adaptation lower application threshold
- p3622 Infeed current controller adaptation reduction factor

1.1.3 Active Infeed open-loop control

Description

The Active Line Module can be controlled via the BICO interconnection by means of terminals or the field bus. The operating status is indicated on the operating display r0002. The missing enable signals for operation (r0002 = 00) are mapped in parameter r0046. The EP terminals (enable pulses) must be connected in accordance with the Equipment Manual.

Acknowledge error

Errors that are still present but the causes of which have been rectified can be acknowledged by means of a 0 → 1 edge at the "Acknowledge error" (p2103.5) signal.

Switching on the Active Line Module:

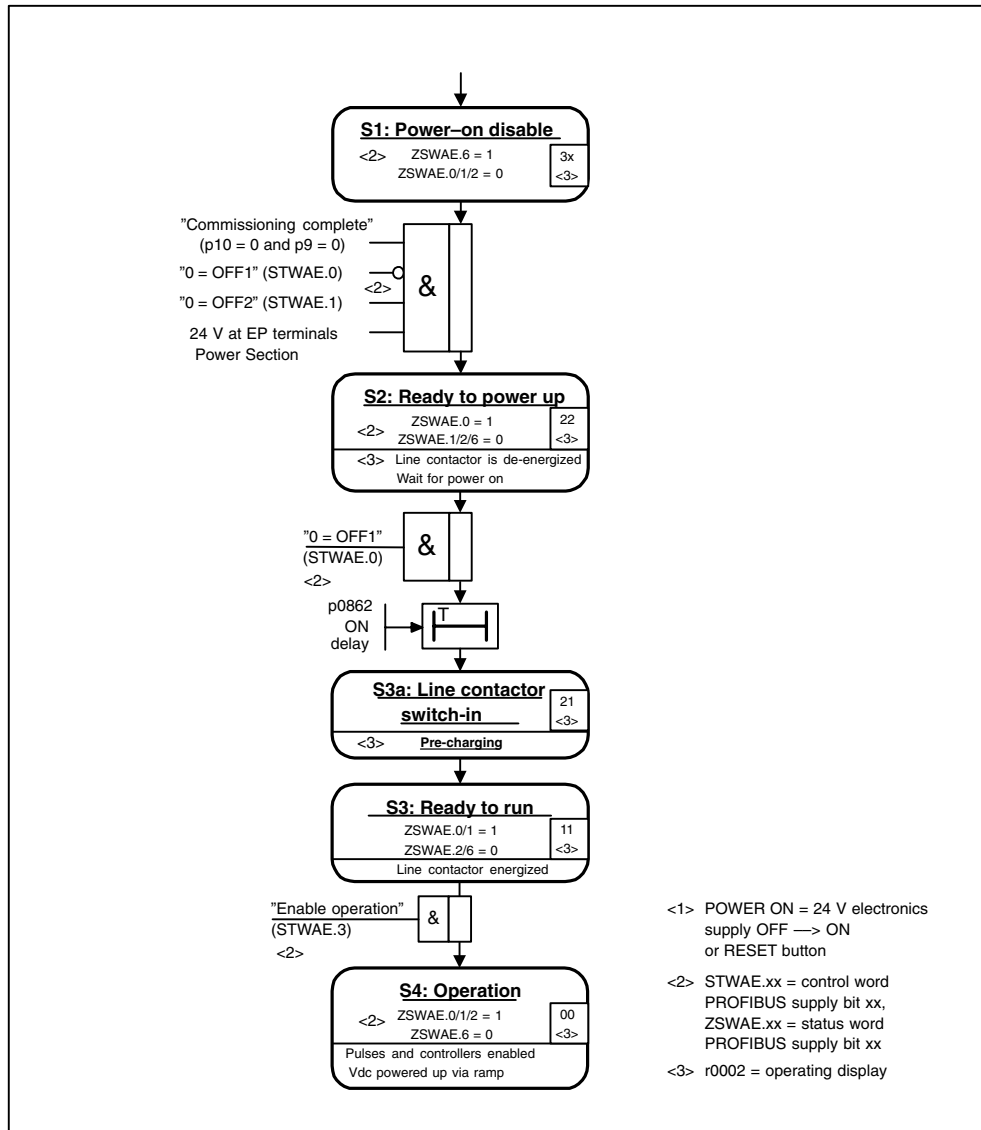


Fig. 1-3 Active Infeed ramp-up

Note

Under the condition that the drive system was commissioned with STARTER and no PROFIBUS telegram was activated, the infeed can be powered-up by issuing an enable signal at the EP terminals and a positive signal edge at OFF1 (p0840).

Switching off the Active Line Module

To switch off the Active Line Module, carry out the steps for switching it on in reverse order.

Switching off the controller with the OFF1 signal is delayed by the time entered in p3490, thereby allowing the connected drives to be decelerated in a controlled manner.

Control and status messages

Table 1-2 Active Infeed open-loop control

Signal name	Internal control word	Binector input	Display of internal control word	PROFIBUS telegram 370
ON/OFF1	STWAE.0	p0840 ON/OFF2	r0898.0	A_STW1.0
OFF2	STWAE.1	p0844 1 OFF2 and p0845 2 OFF2	r0898.1	A_STW1.1
Enable operation	STWAE.3	p0852 Enable operation	r0898.3	A_STW1.3
Disable motor operation	STWAE.5	p3532 Disable motor operation	r0898.5	A_STW1.5
Inhibit regenerating	STWAE.6	p3533 Inhibit regenerating	r0898.6	A_STW1.6
Acknowledge error	STWAE.7	p2103 1 Acknowledge or p2104 2 Acknowledge or p2105 3 Acknowledge	r2138.7	A_STW1.7
Master ctrl by PLC	STWAE.10	p0854 Master ctrl by PLC	r0898.10	A_STW1.10

Table 1-3 Active Infeed status message

Signal name	Internal status word	Parameter	PROFIBUS telegram 370
Ready to power up	ZSWAE.0	r0899.0	A_ZSW1.0
Ready to run	ZSWAE.1	r0899.1	A_ZSW1.1
Operation enabled	ZSWAE.2	r0899.2	A_ZSW1.2
Fault present	ZSWAE.3	r2139.3	A_ZSW1.3
No OFF2 active	ZSWAE.4	r0899.4	A_ZSW1.4
Power-on disable	ZSWAE.6	r0899.6	A_ZSW1.6
Alarm present	ZSWAE.7	r2139.7	A_ZSW1.7
Controlled by PLC	ZSWAE.9	r0899.9	A_ZSW1.9
Pre-charging completed	ZSWAE.11	r0899.11	A_ZSW1.11
Line contactor energized feedback	ZSWAE.12	r0899.12	A_ZSW1.12

1.1.4 Reactive current control

A reactive current setpoint can be set to compensate the reactive current or to stabilize the line voltage in infeed mode. The total setpoint is the sum of the fixed setpoint (p3610) and the dynamic setpoint via binector input p3611.

Note

The direction of rotation of the network is compensated automatically with reactive current control. A negative reactive current setpoint causes an inductive reactive current; a positive setpoint generates a capacitive reactive current.

Note

The closed-loop control limits the reactive current setpoint dynamically in such a way that the sum of the active current setpoint and the reactive current setpoint does not exceed the maximum device current.

Note

The reactive current consumption of the line filter selected in the configuration Wizard is automatically covered by the Active Infeed closed-loop control. This means that the display value of the current reactive current setpoint in 0075 no longer corresponds with the parameterized total reactive current setpoint.

Note

The reactive power setpoint of the Line Module with respect to the network can be derived by multiplying the parameterized total reactive current setpoint by $1.73 \cdot \text{rated line voltage}$.

1.1.5 Harmonics controller

Description

Harmonics in the line voltage cause harmonics in the line currents. By activating the harmonics controller, you can reduce current harmonics.

Example: setting the harmonics controller

The 5th and 7th harmonic are to be compensated:

Table 1-4 Example parameters for the harmonics controller

Index	p3624 harmonics controller order	p3625 scaling
[0]	5	100 %
[1]	7	100 %

The phase currents in parameter p0069[0..2] (U, V, W) can be checked using the STARTER trace function.

Overview: key parameters

- p3624 Infeed harmonics controller order
- p3625 Infeed harmonics controller scaling
- r0069[0..6] Phase current, actual value

1.2 Smart Infeed

1.2.1 Smart Infeed closed-loop control

Features

- For Smart Line Modules with a power of ≥ 16 kW
- Unregulated DC link voltage
- Regenerative feedback capability

Description

The firmware for the Smart Line Modules is on the Control Unit assigned to it. The Smart Line Module and Control Unit communicate via DRIVE-CLiQ.

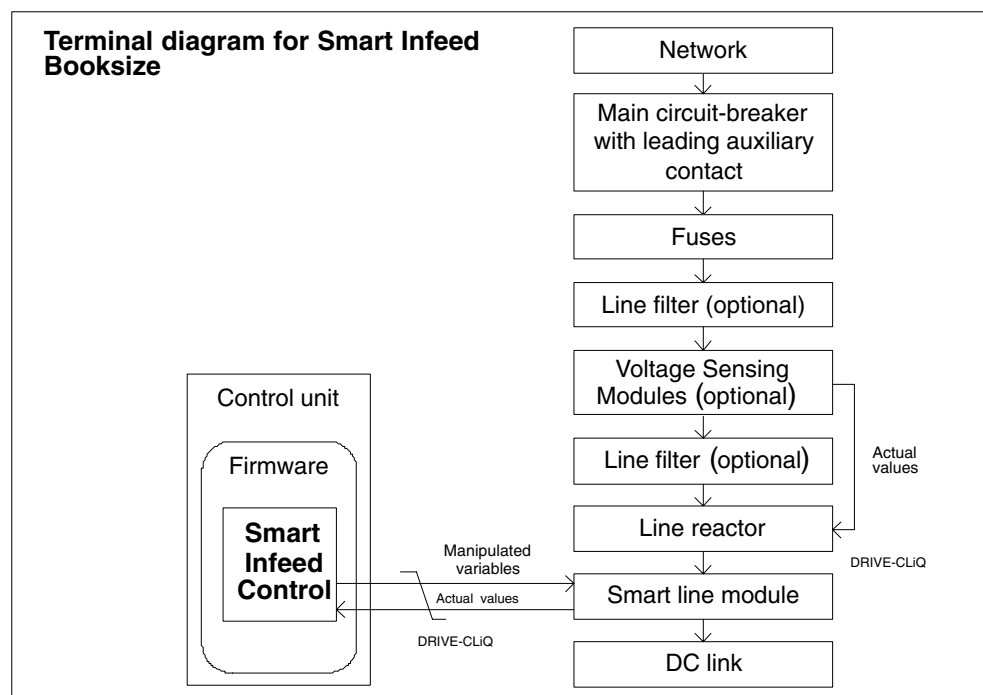


Fig. 1-4 Schematic structure of the Smart Infeed Booksize

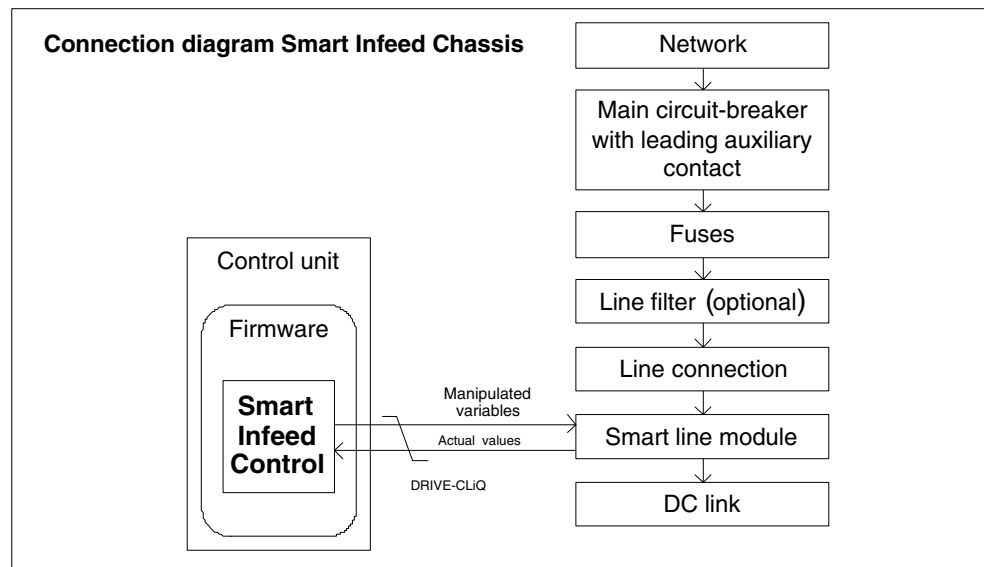


Fig. 1-5 Schematic structure of Smart Infeed Chassis

Commissioning

The device supply voltage (p0210) and the rated line frequency (p0211) must be parameterized during commissioning.

Note

In a supply system without regenerative feedback capability (e.g. generators), regenerative operation must be inhibited via the binector input p3533.

Function diagram for Smart Infeed (refer to the List Manual)

- 1775 Overviews – Smart Infeed
- 8820 Control word sequential control infeed
- 8826 Status word sequential control infeed
- 8828 Status word infeed
- 8832 Sequence control
- 8834 Missing enable signals, line contactor control
- 8850 Smart Infeed interface (control signals, actual values)
- 8860 Supply voltage monitoring
- 8864 Power frequency and Vdc monitoring

Key parameters for Smart Infeed (see List Manual)

Adjustable parameters

- r0002 Infeed/operating display
- r0046 CO/BO: Infeed missing enable signals
- p0210 Device supply voltage
- p0211 Rated line frequency
- p0840 BI: ON/OFF1
- p0844 BI: 1. OFF2
- p0852 BI: Enable operation
- r0898 CO/BO: Control word sequential control infeed
- r0899 CO/BO: Status word sequence control infeed
- r2138 CO/BO: Control word, faults/alarms
- r2139 CO/BO: Status word, faults/alarms 1
- r3405 CO/BO: Status word infeed
- p3533 BI: Infeed, inhibit regenerative operation

1.2.2 Line and DC link identification

The characteristic line supply and DC link quantities are determined using the automatic parameter identification routine. They provide the basis to optimally set the controllers in the Line Module.

Note

If the line supply environment changes, or the components connected to the DC link (e.g. after installing and mounting the equipment at the customer's site or after expanding the drive group), then the line supply/DC link identification routine should be repeated with $p3410 = 5$. Only then can it be guaranteed that the infeed operates with an optimum controller setting.

When the identification function is activated, alarm A06400 is output.

Caution

For Smart Line Modules, Chassis type, the line supply and DC link identification routine is not permissible.

Identification methods

For additional identification methods, see the List Manual.

- $p3410 = 4$: An identification run for the total inductance and DC link capacitance is initiated when the pulses are next enabled (two measuring routines with different current magnitudes). Data determined during identification ($r3411$ and $r3412$) is entered into $p3421$ and $p3422$ and the controller is recalculated. At the same time, the parameters for current controller adaptation are device ($p6320$, $p6322$). All of the parameters for the infeed module are then automatically stored in a non-volatile memory.
The infeed continues to operate without any interruption with the new controller parameters.
- $p3410 = 5$: The same measurements and write operations are always carried-out for $p3410 = 4$. However, before the first identification run, the parameter values for line inductance and DC link capacitance are reset ($p3421 = p0223$ and $p3422 = p0227$) and the coarse settings are made for the controller.
 $p3410$ is automatically set to 0 after an identification run has been successfully completed.

Note:

The identification using $p3410 = 5$ is the preferred method.

Closed-loop control may, for example, have to be reset to the factory setting if the identification process is unsuccessful.

Key parameters for line and DC link identification (see List Manual)

- p3410 Infeed identification method
- p3421 Infeed inductance
- p3422 Infeed DC link capacity

1.2.3 Smart Infeed open-loop control

Description

The Smart Line Module can be controlled via the BICO interconnection by means of terminals or the field bus. The operating status is indicated on the operating display r0002. The missing enable signals for operation (r0002 = 00) are mapped in parameter r0046. The EP terminals (enable pulses) must be connected in accordance with the Equipment Manual.

Acknowledge error

Errors that are still present but the causes of which have been rectified can be acknowledged by means of a 0 → 1 edge at the “Acknowledge error” (p2103.5) signal.

Switching on the Smart Line Module:

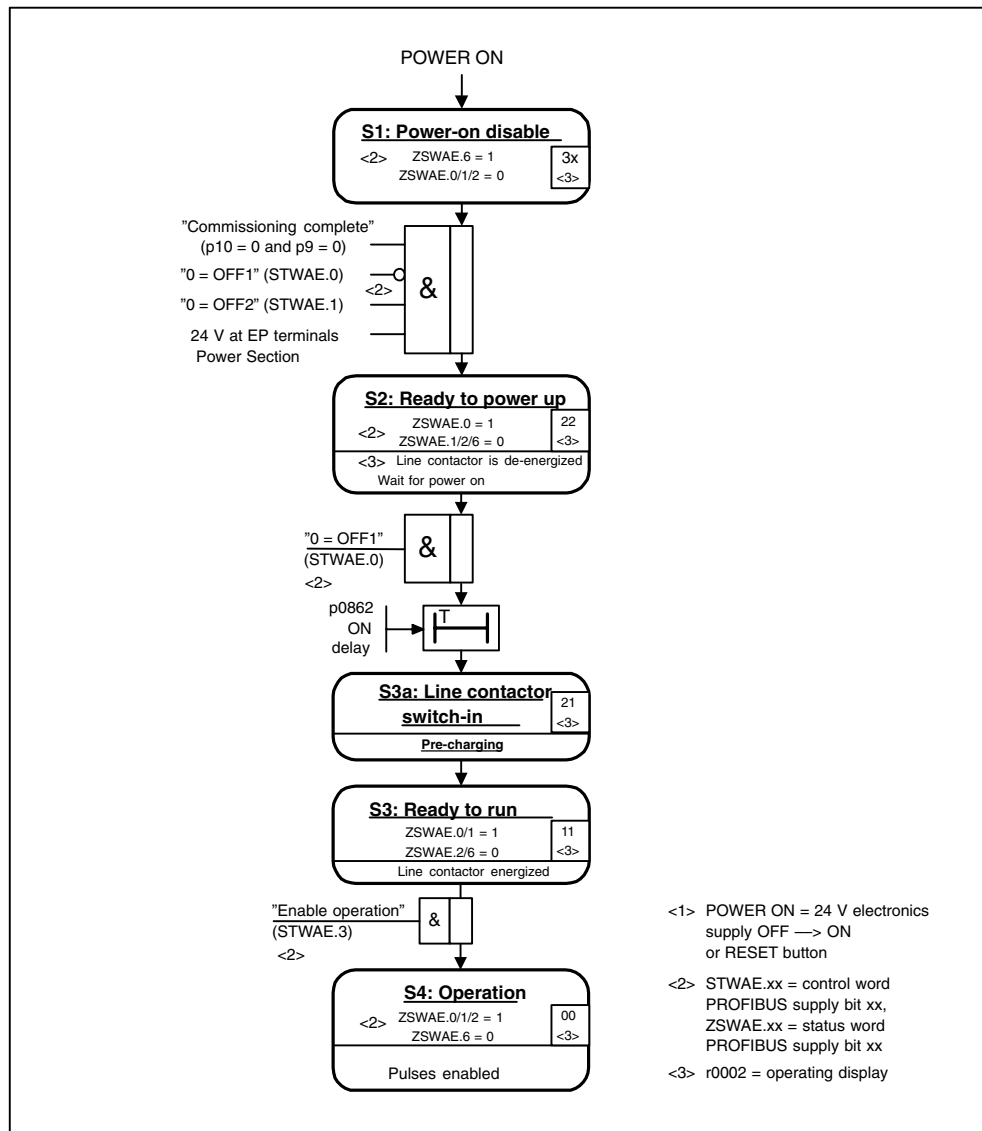


Fig. 1-6 Smart Infeed ramp-up

Note

Under the condition that the drive system was commissioned with STARTER and no PROFIBUS telegram was activated, the infeed can be powered-up by issuing an enable signal at the EP terminals and a positive signal edge at OFF1 (p0840).

Switching off the Smart Line Module

To switch off the Active Line Module, carry out the steps for switching it on in reverse order.

Switching off the controller with the OFF1 signal is delayed by the time entered in p3490, thereby allowing the connected drives to be decelerated in a controlled manner.

Control and status messages

Table 1-5 Smart Infeed open-loop control

Signal name	Internal control word	Binector input	Display of internal control word	PROFIBUS telegram 370
ON/OFF1	STWAE.0	p0840 ON/OFF2	r0898.0	A_STW1.0
OFF2	STWAE.1	p0844 1 OFF2 and p0845 2 OFF2	r0898.1	A_STW1.1
Enable operation	STWAE.3	p0852 Enable operation	r0898.3	A_STW1.3
Inhibit regenerating	STWAE.6	p3533 Inhibit regenerating	r0898.6	A_STW1.6
Acknowledge error	STWAE.7	p2103 1 Acknowledge or p2104 2 Acknowledge or p2105 3 Acknowledge	r2138.7	A_STW1.7
Master ctrl by PLC	STWAE.10	p0854 Master ctrl by PLC	r0898.10	A_STW1.10

Table 1-6 Smart Infeed status message

Signal name	Internal status word	Parameter	PROFIBUS telegram 370
Ready to power up	ZSWAE.0	r0899.0	A_ZSW1.0
Ready to run	ZSWAE.1	r0899.1	A_ZSW1.1
Operation enabled	ZSWAE.2	r0899.2	A_ZSW1.2
Fault present	ZSWAE.3	r2139.3	A_ZSW1.3
No OFF2 active	ZSWAE.4	r0899.4	A_ZSW1.4
Power-on disable	ZSWAE.6	r0899.6	A_ZSW1.6
Alarm present	ZSWAE.7	r2139.7	A_ZSW1.7
Controlled by PLC	ZSWAE.9	r0899.9	A_ZSW1.9
Pre-charging completed	ZSWAE.11	r0899.11	A_ZSW1.11
Line contactor energized feedback	ZSWAE.12	r0899.12	A_ZSW1.12

1.3 Basic Infeed

1.3.1 Basic Infeed open-loop control

Features

- For Basic Line Modules Chassis
- Unregulated DC link voltage

Description

Basic Infeed open-loop control can be used to switch on/off the Basic Line Module. The Basic Line Module is an unregulated infeed unit without regenerative feedback capability.

The open-loop control firmware for the Basic Line Module runs on the Control Unit assigned to it. The Basic Line Module and Control Unit communicate via DRIVE-CLiQ.

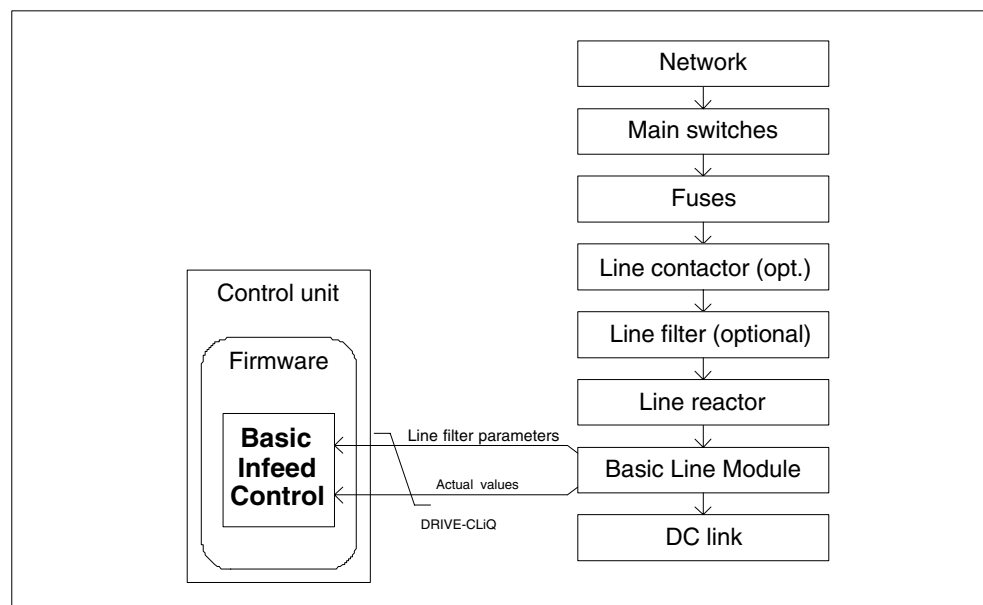


Fig. 1-7 Schematic structure of Basic Infeed Chassis

Commissioning

The rated line voltage (p0210) must be parameterized during commissioning.

Overview of key parameters for Basic Infeed (see List Manual)

- r0002 Infeed/operating display
- r0046 CO/BO: Infeed missing enable signals
- p0210 Device supply voltage
- p0840 BI: ON/OFF1
- p0844 BI: 1st OFF2
- r0898 CO/BO: Control word sequential control infeed
- r0899 CO/BO: Status word sequence control infeed
- r2138 CO/BO: Control word, faults/alarms
- r2139 CO/BO: Status word, faults/alarms 1

Function diagram overview (refer to the List Manual)

- 8720 Control word sequential control infeed
- ...
- 8760 Messages and monitoring functions

1.3.2 Basic Infeed open-loop control

Description

The Basic Line Module can be controlled via the BICO interconnection by means of terminals or the field bus. The operating status is indicated on the operating display r0002. The missing enable signals for operation (r0002 = 00) are mapped in parameter r0046. The EP terminals (enable pulses) must be connected in accordance with the Equipment Manual.

Acknowledge error

Errors that are still present but the causes of which have been rectified can be acknowledged by means of a 0 → 1 edge at the "Acknowledge error" (p2103.5) signal.

Switching on the Basic Line Module:

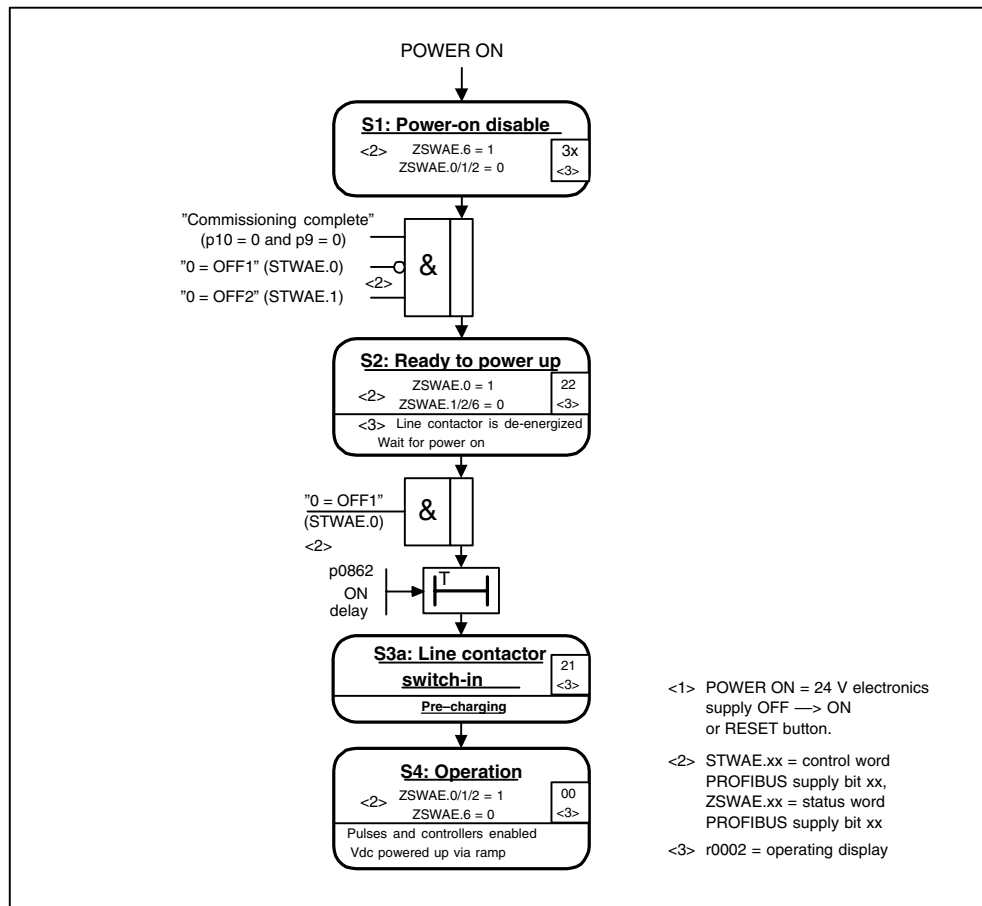


Fig. 1-8 Basic Infeed ramp-up

Note

Under the condition that the drive system was commissioned with STARTER and no PROFIBUS telegram was activated, the infeed can be powered-up by issuing an enable signal at the EP terminals and a positive signal edge at OFF1 (p0840).

Switching off the Basic Line Module

To switch off the Active Line Module, carry out the steps for switching it on in reverse order.

Switching off the controller with the OFF1 signal is delayed by the time entered in p3490, thereby allowing the connected drives to be decelerated in a controlled manner.

Control and status messages

Table 1-7 Basic Infeed open-loop control

Signal name	Internal control word	Binector input	Display of internal control word	PROFIBUS telegram 370
ON/OFF1	STWAE.0	p0840 ON/OFF2	r0898.0	A_STW1.0
OFF2	STWAE.1	p0844 1 OFF2 and p0845 2 OFF2	r0898.1	A_STW1.1
Acknowledge error	STWAE.7	p2103 1 Acknowledge or p2104 2 Acknowledge or p2105 3 Acknowledge	r2138.7	A_STW1.7
Master ctrl by PLC	STWAE.10	p0854 Master ctrl by PLC	r0898.10	A_STW1.10

Table 1-8 Basic Infeed status message

Signal name	Internal status word	Parameter	PROFIBUS telegram 370
Ready to power up	ZSWAE.0	r0899.0	A_ZSW1.0
Ready to run	ZSWAE.1	r0899.1	A_ZSW1.1
Operation enabled	ZSWAE.2	r0899.2	A_ZSW1.2
No OFF2 active	ZSWAE.4	r0899.4	A_ZSW1.4
Power-on disable	ZSWAE.6	r0899.6	A_ZSW1.6
Controlled by PLC	ZSWAE.9	r0899.9	A_ZSW1.9
Pre-charging completed	ZSWAE.11	r0899.11	A_ZSW1.11
Line contactor energized feedback	ZSWAE.12	r0899.12	A_ZSW1.12

1.4 Line contactor control

Description

This function can be used to control an external line contactor. Opening and closing the line contactor can be monitored by evaluating the feedback contact in the line contactor. The line contactor is used for the electrical isolation of the DC link for the energy supply network.

The line contactor can be controlled using the following drive objects:

- Via bit r0863.1 of drive object INFEED
- Via bit r0863.1 of drive object SERVO/VECTOR

Note

For more information on the line connection, see the Equipment Manuals.

Example of commissioning line contactor control

Assumption:

- Line contactor control via a digital output of the Control Unit (DI/DO 8)
- Line contactor feedback via a digital input of the Control Unit (DI/DO 9)
- Line contactor switching time less than 100 ms

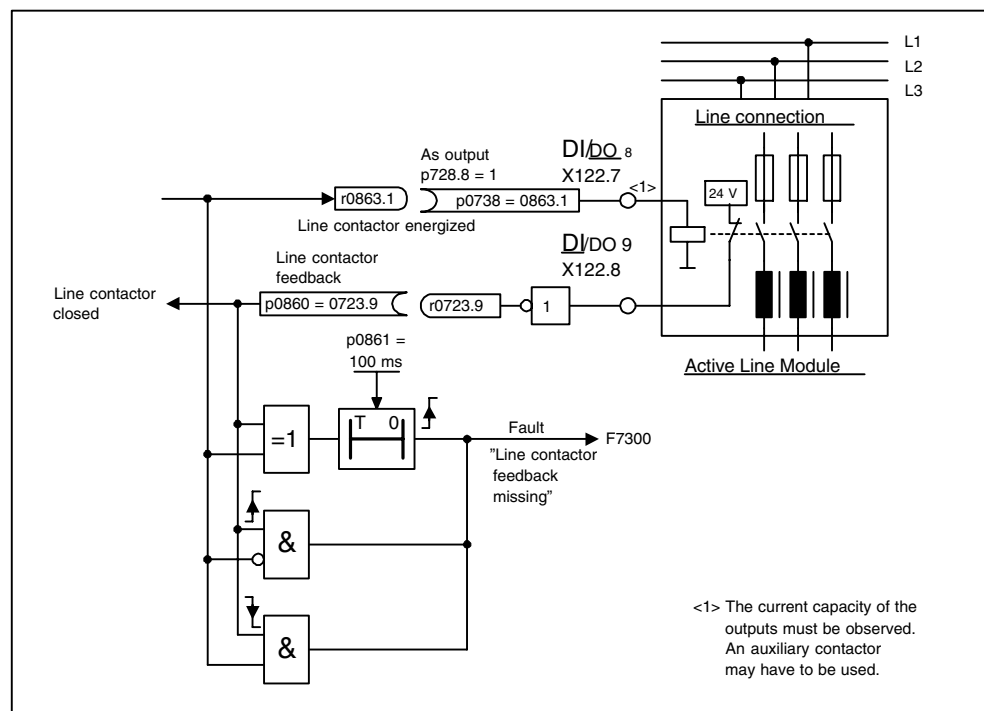


Fig. 1-9 Line contactor control

Commissioning steps:

- Connect the line contactor control contact to DI/DO 8.

Note

Note the current carrying capacity of the digital output (see the Equipment Manual). A line contactor may have to be used.

- Parameterize DI/DO 8 as an output (p728.8 = 1).
- Assign p0738 the control signal for the line contactor r0863.1.
- Connect the line contactor feedback contact to DI/DO 9.
- Assign p0860 an inverted input signal r0723.9.
- Enter the monitoring time for the line contactor (100 ms) in p0861.

Function diagram overview (refer to the List Manual)

- 8934 Missing enable signals, line contactor control

Parameter overview (see List Manual)

- r0863.1 CO/BO: Drive coupling status word/control word
- p0860 BI: Line contactor, feedback signal

1.5 Pre-charging and bypass contactor chassis

Description

Pre-charging is the procedure for charging the DC link capacitors via resistors. Pre-charging is normally carried out from the feeding supply network, although it can also be carried out from a pre-charged DC link. The pre-charging input circuit limits the charging current of the DC link capacitors.

The pre-charging input circuit for Active and Smart Infeed in the chassis design comprises a pre-charging contactor with pre-charging resistors and a bypass contactor. The Active Line Module controls the pre-charging input circuit in the Active Interface Module via terminals.

The pre-charging input circuit in the Active Interface Module of module types FI and GI contains the bypass contactor. For sizes HI and JI, the bypass contactor must be separately provided.

For Smart Line Modules, the pre-charging itself is part of the Smart Line Module; however, the bypass contactor must be externally mounted and installed.

Additional information: see the Equipment Manual.

Procedure during power ON/OFF

Power ON:

- The pre-charging contactor is closed and the DC link is charged via the pre-charging resistors.
- Once pre-charging is complete, the bypass contactor is closed and the pre-charging contactor opened. The DC link is pre-charged and ready for operation.
If pre-charging could not be completed, fault F06000 is output.

Power OFF:

- The pulses are inhibited and the bypass contactor is then opened.



Extended Setpoint Channel

2

2.1 Extended setpoint channel servo

Description

In the servo operating mode, the extended setpoint channel is deactivated by default. If an extended setpoint channel is required, then this must be activated (refer to the next section “Activating the function module “extended setpoint channel” in the servo operating mode”).

Properties of servo mode without the “extended setpoint channel” function module

- The setpoint is directly interconnected to p1155[D] (e.g. from a higher-level control or technology controller)
- A higher number of motors can be controlled with one Control Unit at one setpoint source by moving the ramp-function generator to the higher-level controller.
- Dynamic Servo Control (DSC) only
When using DSC, the “extended setpoint channel” is not used. This unnecessarily uses the computation time of the Control Unit and, for servo, can be de-activated.
- Deceleration ramp OFF1 via p1121[D]
- Deceleration ramp OFF3 via p1135[D]
- For PROFIdrive telegrams 2 to 106 and 999 only (free assignment)
- STW 1 bit 5 (freeze ramp-function generator), no function

2.1.1 Dynamic Servo Control (DSC)

Description

The Dynamic Servo Control (DSC) function enables the actual position value to be evaluated in a fast speed controller cycle directly in the drive. The position setpoint is predefined in the position control cycle by the higher-level controller (e.g. SIMOTION via the isochronous PROFIBUS with PROFIdrive telegrams, standard telegrams 5 and 6, SIEMENS telegram 105, 106, 116 (not telegram type 1 or 999).

DSC enables high position controller gain and, as a result, minimizes following errors and provides a high level of noise immunity.

Function diagram overview (refer to the List Manual)

- 3090 Dynamic Servo Control (DSC)

Parameter overview (see List Manual)

- p1190 CI: DSC position deviation XERR
- p1191 CI: DSC position controller gain KPC
- p1192[D] DSC encoder selection
- p1193[D] DSC encoder adaptation factor

2.1.2 Activating the “extended setpoint channel” function module in servo mode

In servo mode, the “extended setpoint channel” function module can be activated via the commissioning Wizard or the drive configuration (configure DDS).

You can check the current configuration in parameter r0108.8.

Once you have set the configuration, you have to download it to the Control Unit where it is stored in a non-volatile memory (see Section 5.1).

Note

When the “extended setpoint channel” function module for servo is activated, under certain circumstances, the number of drives in the multi-axis group that can be controlled from a Control Unit is reduced.

2.2 Extended setpoint channel

2.2.1 Description

In the extended setpoint channel, setpoints from the setpoint source are conditioned for motor control.

The setpoint for motor control can also originate from the technology controller (see Technology Controller).

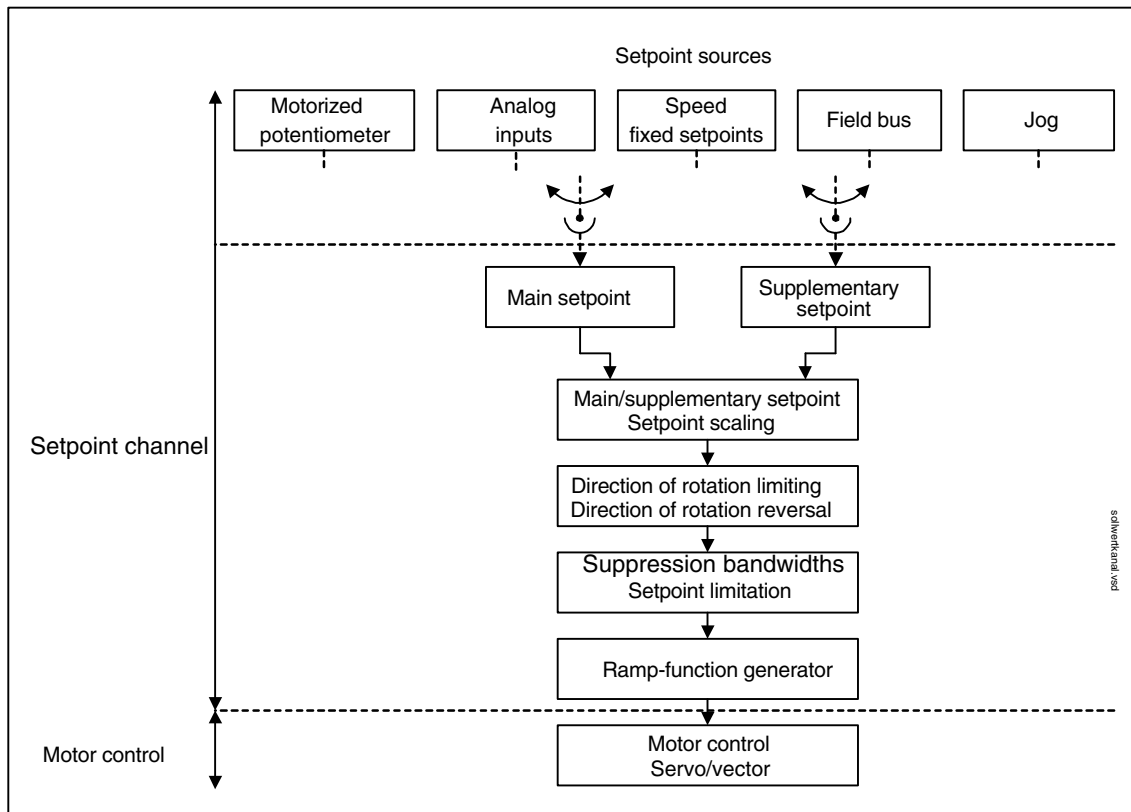


Fig. 2-1 Extended setpoint channel

Properties of the extended setpoint channel

- Main/supplementary setpoint, setpoint scaling
- Direction of rotation limiting and direction of rotation changeover
- Suppression bandwidths and setpoint limitation

Setpoint sources

The closed-loop control setpoint can be interconnected from various sources using BICO technology, e. g. to p1070 CI: main setpoint (see function diagram 3030).

There are various options for setpoint input:

- Fixed speed setpoints
- Motorized potentiometer
- Jog
- Field bus
 - e.g. setpoint via PROFIBUS
- Via the analog inputs on the following components:
 - Terminal Board 30 (TB30)
 - Terminal Module 31 (TM31)

2.2.2 Jog

Description

This function can be selected via digital inputs or via a field bus (e.g. PROFIBUS). The setpoint is, therefore, predefined via p1058[D] and p1059[D].

When a jog signal is present, the motor is accelerated to the jog setpoint with the acceleration ramp of the ramp-function generator (referred to the maximum speed p1082; see Fig. 2-3). After the jog signal has been deselected, the motor is decelerated via the set ramp of the ramp-function generator.

Caution

The jog function is not PROFIdrive compatible!

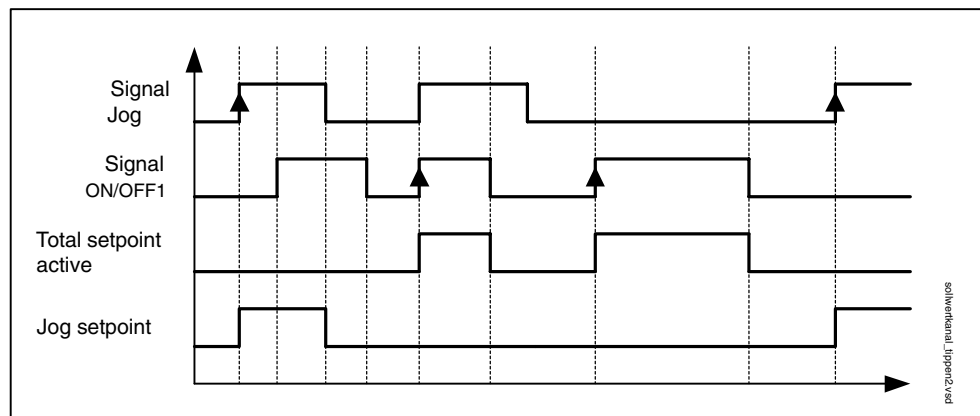


Fig. 2-2 Function chart: Jog and OFF1

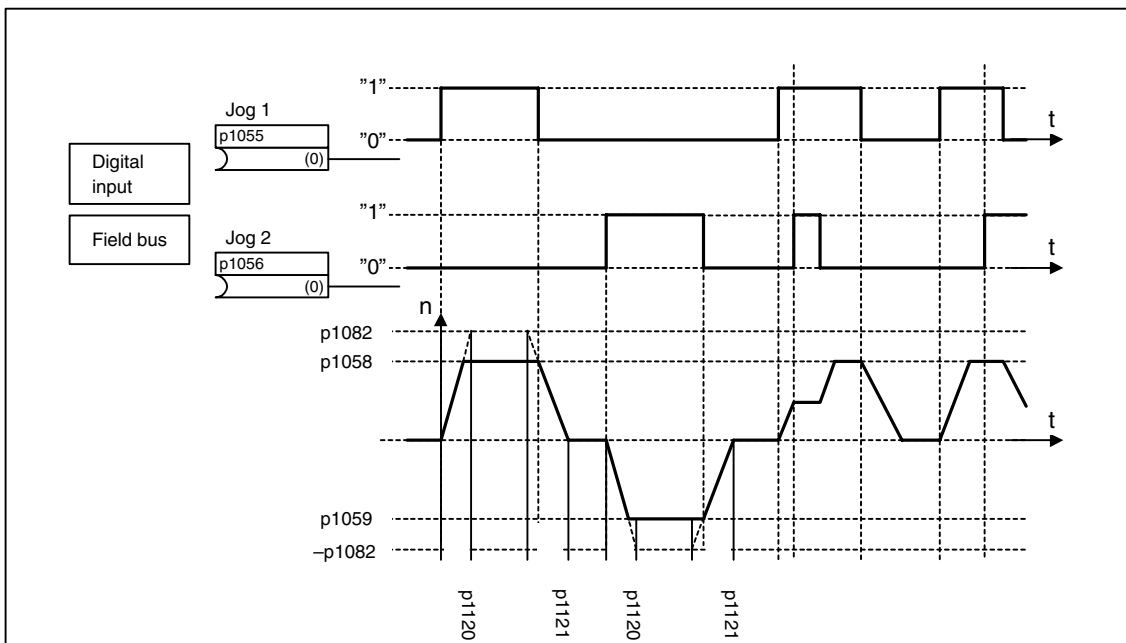


Fig. 2-3 Function chart: Jog1 and jog2

Jog properties

- If both jog signals are issued at the same time, the current speed is maintained (constant velocity phase).
- Jog setpoints are approached and exited via the ramp-function generator.
- The jog function can be activated from the “ready to start” status and from the OFF1 deceleration ramp.
- If ON/OFF1 = “1” and jog are selected simultaneously, ON/OFF1 has priority.
- OFF2 and OFF3 have priority over jogging.
- If the ON/OFF1 command is present after the jog signal has been removed (ON/OFF1 = 1), the “normal” speed setpoint is activated via the ramp-function generator.
- In jog mode, the main speed setpoints (r1078) and the supplementary setpoints 1 and 2 (p1155 and p1160) are inhibited.
- The suppression bandwidths (p1091 ... p1094) and the minimum limit (p1080) in the setpoint channel are also active in jog mode.
- In jog mode, ZSWA.02 (operation enabled) is set to “0” because the speed setpoint has not been enabled for control.
- The ramp-function generator cannot be frozen (via p1141) in jog mode (r0046.31 = 1).

Jog sequence

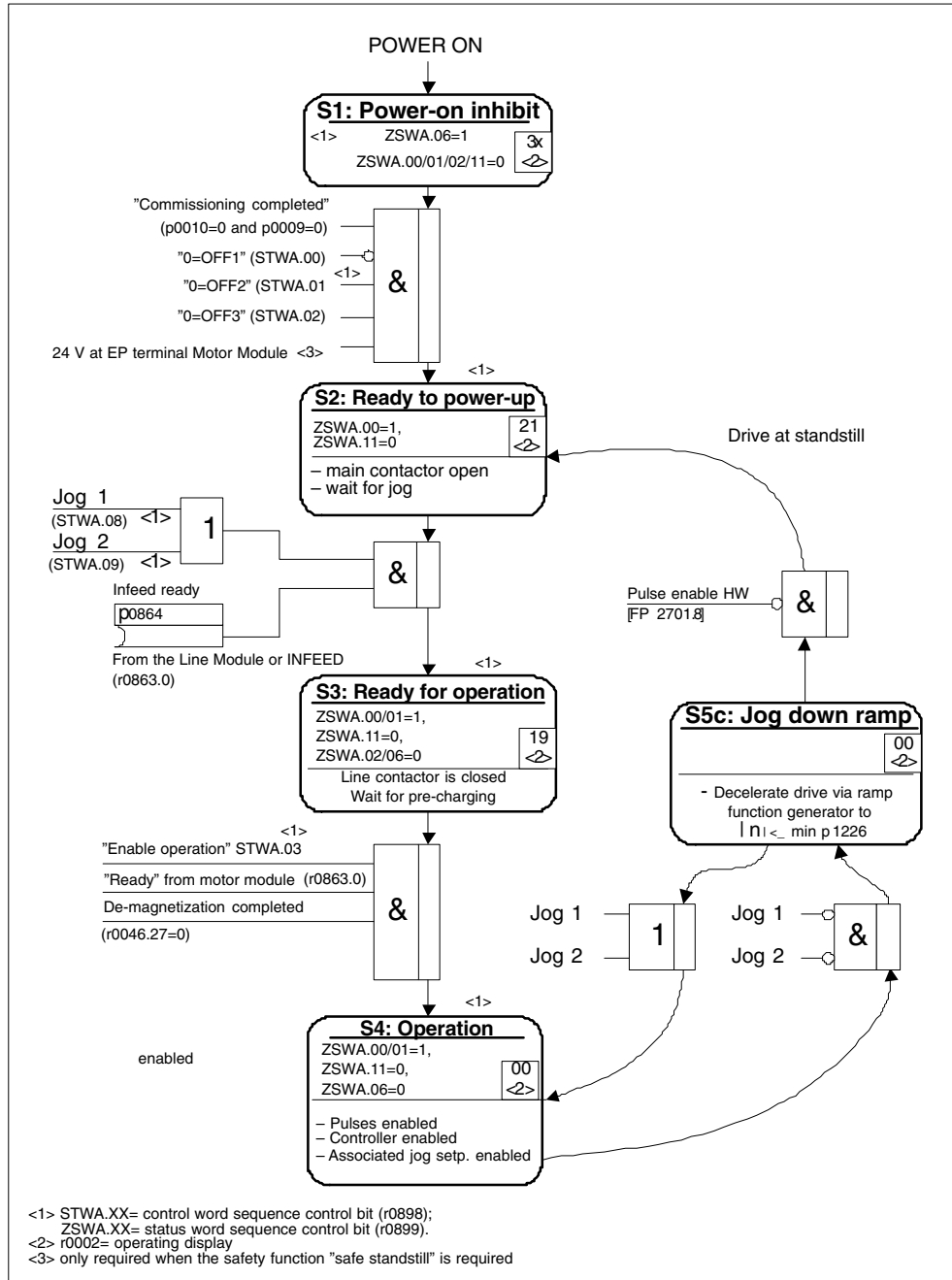


Fig. 2-4 Jog sequence

Control and status messages

Table 2-1 Jog control

Signal name	Internal control word	Binector input	PROFIBUS telegram 2 ... 106
0 = OFF1	STWA.00	p0840 ON/OFF1	STW1.0
0 = OFF2	STWA.01	p0844 1. OFF2 p0845 2. OFF2	STW1.1
0 = OFF3	STWA.02	p0848 1. OFF3 p0849 2. OFF3	STW1.2
Enable operation	STWA.3	p0852 Enable operation	STW1.3
Jog 1	STWA.8	p1055 Jog bit 0	STW1.8
Jog 2	STWA.9	p1056 Jog bit 1	STW1.9

Table 2-2 Jog status message

Signal name	Internal status word	Parameter	PROFIBUS telegram 2 ... 106
Ready to power up	ZSWA.0	r0899.0	ZSW1.0
Ready to run	ZSWA.1	r0899.1	ZSW1.1
Operation enabled	ZSWA.2	r0899.2	ZSW1.2
Power-on disable	ZSWA.6	r0899.6	ZSW1.6
Pulses enabled	ZSWA.11	r0899.11	ZSW1.11

Function diagram overview (refer to the List Manual)

- 2610 Sequence control
- 3030 Main/added setpoint, setpoint scaling, jogging

Parameter overview (see List Manual)

- p1055[C] BI: Jog bit 0
- p1056[C] BI: Jog bit 1
- p1058[D] Jog 1 speed setpoint
- p1059[D] Jog 2 speed setpoint
- p1082[D] Maximum speed
- p1120[D] Ramp-function generator ramp-up time
- p1121[D] Ramp-function generator ramp-down time

Parameterization with STARTER

The “Speed setpoint jog” parameter screen is selected via the following icon in the toolbar of the STARTER commissioning tool:



Fig. 2-5 STARTER icon for “speed setpoint”

2.2.3 Fixed speed setpoints

Description

This function can be used to specify preset speed setpoints. The fixed setpoints are defined in parameters and selected via binector inputs. Both the individual fixed setpoints and the effective fixed setpoint are available for further interconnection via a connector output (e.g. to connector input p1070 – CI: main setpoint).

Properties

- Number of fixed setpoints: Fixed setpoint 1 to 15
- Selection of fixed setpoints: Binector input bits 0 to 3
 - Binector input bits 0, 1, 2 and 3 = 0 → setpoint = 0 active
 - Unused binector inputs have the same effect as a “0” signal

Function diagram overview (refer to the List Manual)

- 1550 Overviews – setpoint channel
- 2503 Status word sequence control
- 3010 Fixed speed setpoints

Parameter overview (see List Manual)

Adjustable parameters

- p1001[D] CO: Fixed speed setpoint 1
- ...
- p1015[D] CO: Fixed speed setpoint 15
- p1020[C] BI: Fixed speed setpoint selection Bit 0
- p1021[C] BI: Fixed speed setpoint selection Bit 1
- p1022[C] BI: Fixed speed setpoint selection Bit 2
- p1023[C] BI: Fixed speed setpoint selection Bit 3

Visualization parameters

- r1024 CO: Fixed speed setpoint effective
- r1197 Fixed speed setpoint current number

Parameterization with STARTER

In the STARTER commissioning tool, the “Fixed setpoints” parameter screen in the project navigator under the relevant drive is activated by double-clicking Setpoint channel → Fixed setpoints.

2.2.4 Motorized potentiometer

Description

This function is used to simulate an electromechanical potentiometer for setpoint input.

You can switch between manual and automatic mode for setpoint input. The specified setpoint is routed to an internal ramp-function generator.

The output of the ramp-function generator for the motorized potentiometer is available for further interconnection via a connector output (e.g. interconnection to connector input p1070 – CI: main setpoint).

Properties for manual mode (p1041 = "0")

- Separate binector inputs for Raise and Lower are used to adjust the input setpoint:
 - p1035 BI: Motorized potentiometer, setpoint, raise
 - p1036 BI: Motorized potentiometer, lower setpoint
- Invert setpoint (p1039)
- Configurable ramp-function generator, e.g.:
 - Ramp-up/ramp-down time (p1047/p1048) referred to p1082
 - Setting value (p1043/p1044)
 - Initial rounding-off active/not active (p1030.2)
- Non-volatile storage via p1030.3
- Configurable setpoint for Power On (p1030.0)
 - Starting value is the value in p1040 (p1030.0 = 0)
 - Starting value is the stored value (p1030.0 = 1)

Properties for automatic mode (p1041 = "1")

- The input setpoint is specified via a connector input (p1042).
- The motorized potentiometer acts like a "normal" ramp-function generator.
- Configurable ramp-function generator, e.g.:
 - Switch on/off (p1030.1)
 - Ramp-up/ramp-down time (p1047/p1048)
 - Setting value (p1043/p1044)
 - Initial rounding-off active/not active (p1030.2)
- Non-volatile storage of the setpoints via p1030.3
- Configurable setpoint for Power On (p1030.0)
 - Starting value is the value in p1040 (p1030.0 = 0)
 - Starting value is the stored value (p1030.0 = 1)

Function diagram overview (refer to the List Manual)

- 1550 Setpoint channel
- 2501 Control word sequence control
- 3020 Motorized potentiometer

Parameter overview (see List Manual)

- p1030[D] Motorized potentiometer, configuration
- p1035[C] BI: Motorized potentiometer, setpoint, raise
- p1036[C] BI: Motorized potentiometer, lower setpoint
- p1037[D] Motorized potentiometer, maximum speed
- p1038[D] Motorized potentiometer, minimum speed
- p1039[C] BI: Motorized potentiometer, inversion
- p1040[D] Motorized potentiometer, starting value
- p1041[C] BI: Motorized potentiometer, manual/automatic
- p1042[C] CI: Motorized potentiometer, automatic setpoint
- p1043[C] BI: Motorized potentiometer, accept setpoint
- p1044[C] CI: Motorized potentiometer, setting value
- r1045 CO: Motorized potentiometer, speed setpoint in front of the ramp-function generator
- p1047[D] Motorized potentiometer, ramp-up time
- p1048[D] Motorized potentiometer, ramp-down time
- r1050 CO: Motorized potentiometer, setpoint after the ramp-function generator
- p1082[D] Maximum speed

Parameterization with STARTER

In the STARTER commissioning tool, the “Motorized potentiometer” parameter screen in the project navigator under the relevant drive is activated by double-clicking Setpoint channel → Motorized potentiometer.

2.2.5 Main/supplementary setpoint and setpoint modification

Description

The supplementary setpoint can be used to incorporate correction values from lower-level controllers. This can be easily carried out using the addition point for the main/supplementary setpoint in the setpoint channel. Both variables are imported simultaneously via two separate or one setpoint source and added in the setpoint channel.

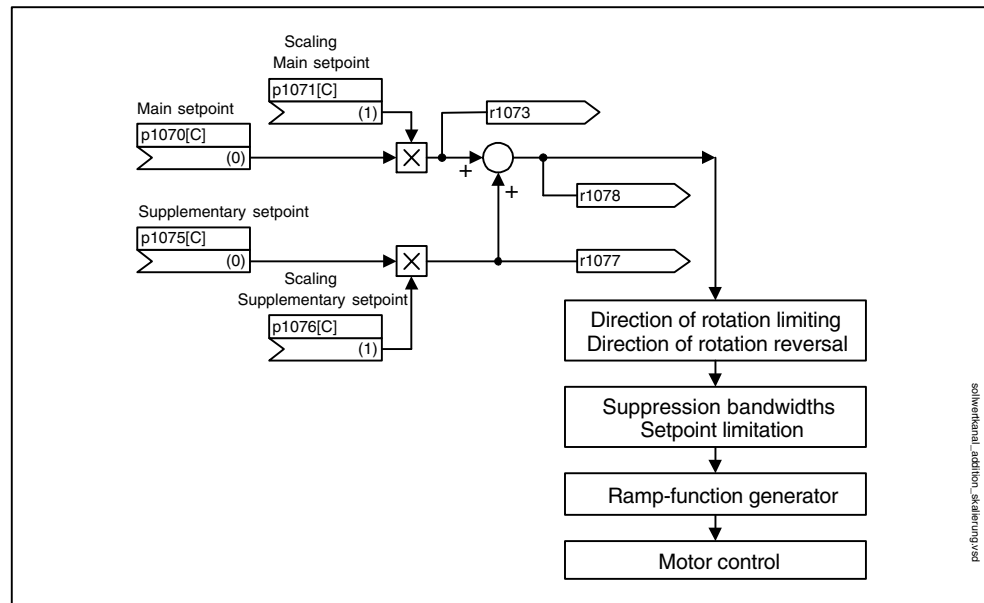


Fig. 2-6 Setpoint addition, setpoint scaling

Function diagram overview (refer to the List Manual)

- 1550 Setpoint channel
- 3030 Main/supplementary setpoint, setpoint scaling, jogging

Parameter overview (see List Manual)

Adjustable parameters

- p1070[C] CI: Main setpoint
- p1071[C] CI: Main setpoint scaling
- p1075[C] CI: Supplementary setpoint
- p1076[C] CI: Supplementary setpoint scaling

Visualization parameters

- r1073[C] CO: Main setpoint effective
- r1077[C] CO: Supplementary setpoint effective
- r1078[C] CO: Total setpoint effective

Parameterization with STARTER

The “speed setpoint” parameter screen is selected via the following icon in the toolbar of the STARTER commissioning tool:



Fig. 2-7 STARTER icon for “speed setpoint”

2.2.6 Direction of rotation limiting and direction of rotation changeover

Description

A reverse operation involves a direction reversal. A direction reversal in the setpoint channel can be triggered by selecting direction reversal p1113[C].

If, on the other hand, a negative or positive setpoint is not to be preselected via the setpoint channel, this can be prevented via parameter p1110[C] or p1111[C].

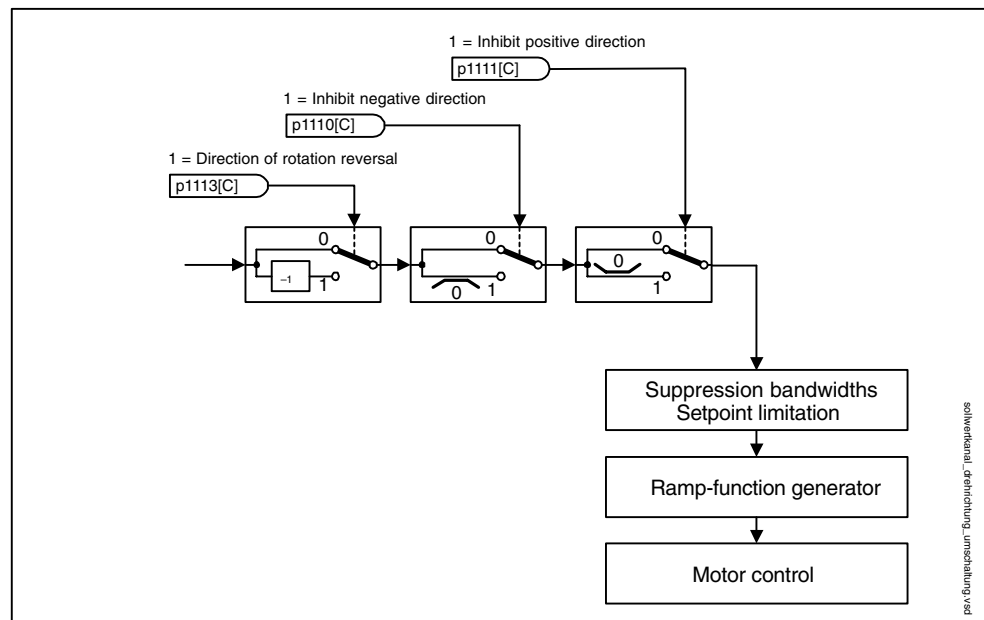


Fig. 2-8 Direction of rotation limiting and direction of rotation changeover

Function diagram overview (refer to the List Manual)

- 1550 Setpoint channel
- 3040 Direction of rotation limiting and direction of rotation changeover

Parameter overview (see List Manual)

Adjustable parameters

- p1110[C] BI: Inhibit negative direction
- p1111[C] BI: Inhibit positive direction
- p1113[C] BI: Direction reversal

Parameterization with STARTER

The “speed setpoint” parameter screen is selected via the following icon in the toolbar of the STARTER commissioning tool:



Fig. 2-9 STARTER icon for “speed setpoint”

2.2.7 Suppression bandwidths and setpoint limits

Description

In the range 0 U/min to setpoint speed, a drive train (e.g. motor, coupling, shaft, machine) can have one or more points of resonance, which can result in vibrations. The suppression bandwidths can be used to prevent operation in the resonance frequency range.

The limit frequencies can be set via p1080[D] and p1082[D]. These limits can also be changed during operation with connectors p1085[C] and p1088[C].

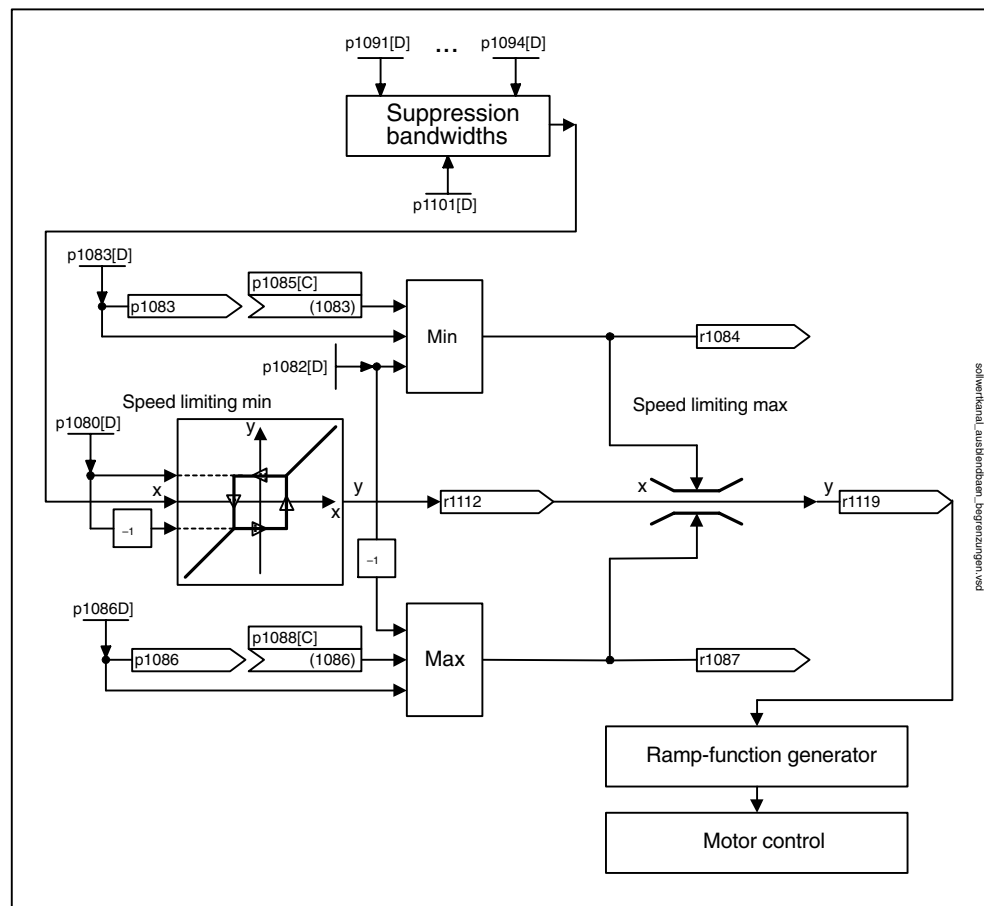


Fig. 2-10 Suppression bandwidths, setpoint limitation

Function diagram overview (refer to the List Manual)

- 1550 Setpoint channel
- 3050 Suppression bandwidth and speed limiting

Parameter overview (see List Manual)

Setpoint limitation

- p1080[D] Minimum speed
- p1082[D] Maximum speed
- p1083[D] CO: Speed limit in positive direction of rotation
- r1084 Speed limit positive effective
- p1085[C] CI: Speed limit in positive direction of rotation
- p1086[D] CO: Speed limit negative direction of rotation
- r1087 Speed limit negative effective
- p1088[C] DI: Speed limit negative direction of rotation
- r1119 Ramp-function generator setpoint at the input

Suppression bandwidths

- p1091[D] Suppression speed 1
- ...
- p1094[D] Suppression speed 4
- p1101[D] Suppression speed bandwidth

Parameterization with STARTER

The “speed limitation” parameter screen is selected by activating the following icon in toolbar of the STARTER commissioning tool:



Fig. 2-11 STARTER icon for “speed limitation”

2.2.8 Ramp-function generator

Description

The ramp-function generator is used to limit acceleration in the event of abrupt setpoint changes, which helps prevent load surges throughout the drive train. The ramp-up time p1120[D] and ramp-down time p1121[D] can be used to set an acceleration ramp and a deceleration ramp independently of each other. This allows a controlled transition to be made in the event of setpoint changes.

The maximum speed p1082[D] is used as a reference value for calculating the ramps from the ramp-up and ramp-down times. A special adjustable ramp can be set via p1135 for fast stop (OFF3), e.g. for rapid controlled deceleration when an emergency stop button is pressed.

There are two types of ramp-function generator:

- Simple ramp-function generator with
 - Acceleration and deceleration ramps
 - Ramp for fast stop (OFF3)
 - Tracking can be selected via a binector input
 - Setting values for the ramp-function generator
- Extended ramp-function generator with
 - Initial and final rounding off

Note

The ramp-function generator cannot be frozen (via p1141) in jog mode (r0046.31 = 1).

Properties of the simple ramp-function generator

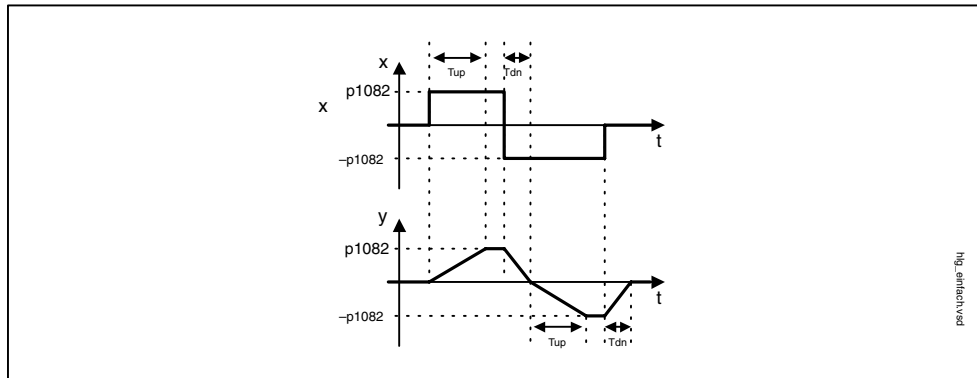


Fig. 2-12 Ramp-up and ramp-down with the simple ramp-function generator

- RFG ramp-up time T_{up} p1120[D]
- RFG ramp-down time T_{dn} p1121[D]
- OFF 3 deceleration ramp
 - OFF3 ramp-down time p1135[D]
- Set ramp-function generator
 - Ramp-function generator setting value p1144[C]
 - Set ramp-function generator signal p1143[C]

Properties of the extended ramp-function generator

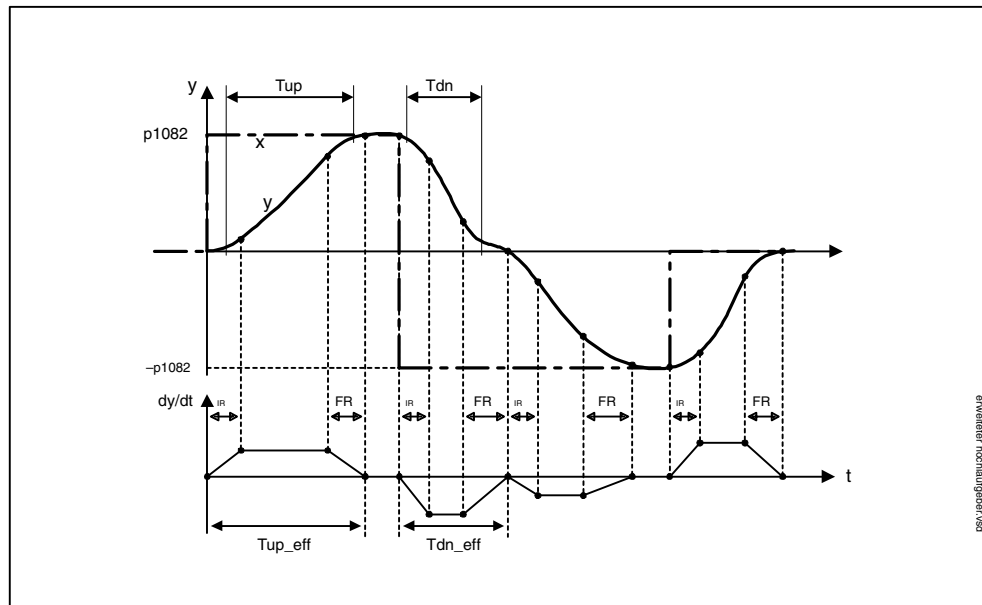


Fig. 2-13 Expanded ramp-function generator

- RFG ramp-up time T_{up} p1120[D]
- RFG ramp-down time T_{dn} p1121[D]

- Initial rounding-off time IR p1130[D]
- Final rounding-off time FR p1131[D]
- Rounding-off type p1134[D]
- Effective ramp-up time
 $T_{up_eff} = T_{up} + (IR/2 + FR/2)$
- Effective ramp-down time
 $T_{dn_eff} = T_{dn} + (IR/2 + FR/2)$
- OFF 3 deceleration ramp
 - OFF3 ramp-down time p1135[D]
 - OFF3 initial rounding-off time p1136[D]
 - OFF3 final rounding-off time p1137[D]
- Set ramp-function generator
 - Ramp-function generator setting value p1144[C]
 - Set ramp-function generator signal p1143[C]
- Ramp-function generator rounding-off type p1134[D]
 - p1134 = "0": Rounding is always active. Can result in overshoot.
 - p1134 = "1": Final rounding-off is not active if the input word is reduced abruptly during ramp-up.

Ramp-function generator tracking

Ramp-function generator tracking allows the speed setpoint to be corrected in line with the actual speed value. p1145 can be used to deactivate ramp-function generator tracking (p1145 = 0) or set the permissible following error (p1145 > 0). If the permissible following error is exceeded, the minimum speed is defaulted that results in the maximum torque.

Ramp-function generator tracking can be activated for the simple and the extended ramp-function generators.

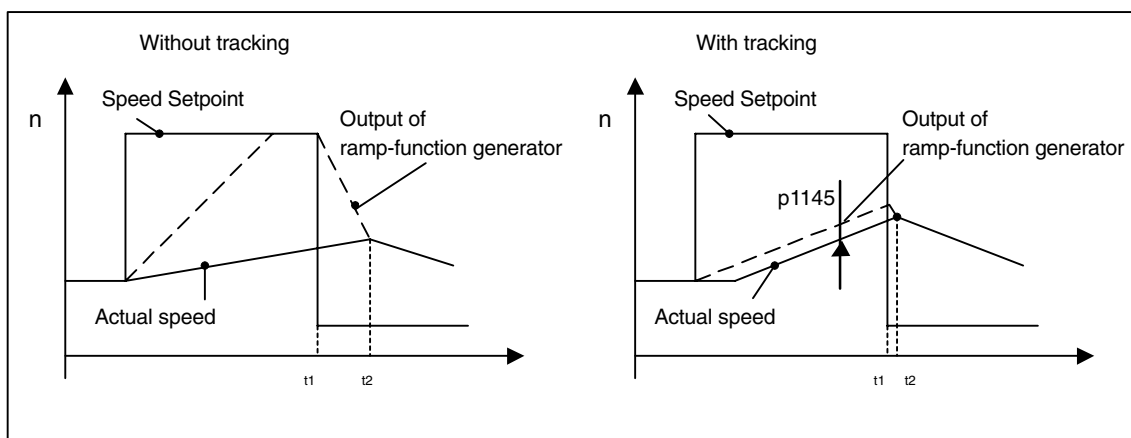


Fig. 2-14 Ramp-function generator tracking

Without ramp-function generator tracking

- $p1145 = 0$
- Drive accelerates until $t2$ although setpoint < actual value

With ramp-function generator tracking

- $p1145 > 0$
- Ramp-function generator output leads setpoint by only a small margin
- $t1$ and $t2$ almost identical

Function diagram overview (refer to the List Manual)

- 1550 Setpoint channel
- 3060 Simple ramp-function generator
- 3070 Extended ramp-function generator
- 3080 Ramp-function generator selection, status word, tracking

Signal overview (see List Manual)

- Control signal STW1.2 OFF3
- Control signal STW1.4 Enable ramp-function generator
- Control signal STW1.5 Start/stop ramp-function generator
- Control signal STW1.6 Enable setpoint
- Control signal STW2.1 Bypass ramp-function generator

Parameterization with STARTER

The “ramp-function generator” parameter screen is selected via the following icon in the toolbar of the STARTER commissioning tool:



Fig. 2-15 STARTER icon for “ramp-function generator”

Parameter overview (see List Manual)

Adjustable parameters

- $p1115$ Ramp-function generator selection
- $p1120[D]$ Ramp-function generator ramp-up time
- $p1121[D]$ Ramp-function generator ramp-down time
- $p1122[C]$ BI: Bypass ramp-function generator

- p1130[D] Ramp-function generator initial rounding-off time
- p1131[D] Ramp-function generator final rounding-off time
- p1134[D] Ramp-function generator rounding-off type
- p1135[D] OFF3 ramp-down time
- p1136[D] OFF3 initial rounding-off time
- p1137[D] OFF3 final rounding-off time
- p1140[C] BI: Enable ramp generator
- p1141[C] BI: Start ramp-function generator
- p1143[C] BI: Ramp-function generator, accept setting value
- p1144[C] CI: Ramp-function generator setting value
- p1145[D] Ramp-function generator tracking

Visualization parameters

- r1119 CO: Ramp-function generator setpoint at the input
- r1150 CO: Ramp-function generator speed setpoint at the output



Notes

Operating Modes

3

3.1 Servo control

This type of closed-loop control enables operation with a high dynamic response and precision for a motor with a motor encoder.

3.1.1 Speed controller

The speed controller controls the motor speed using the actual values from the encoder (operation with encoder) or the calculated actual speed value from the electric motor model (operation without encoder).

Properties

- Speed setpoint filter
- Speed controller adaptation

Note

Speed and torque cannot be controlled simultaneously. If speed control is activated, this has priority over torque control.

Limits

The maximum speed p1082[D] is defined with default values for the selected motor and becomes active during commissioning. The ramp-function generators refer to this value.

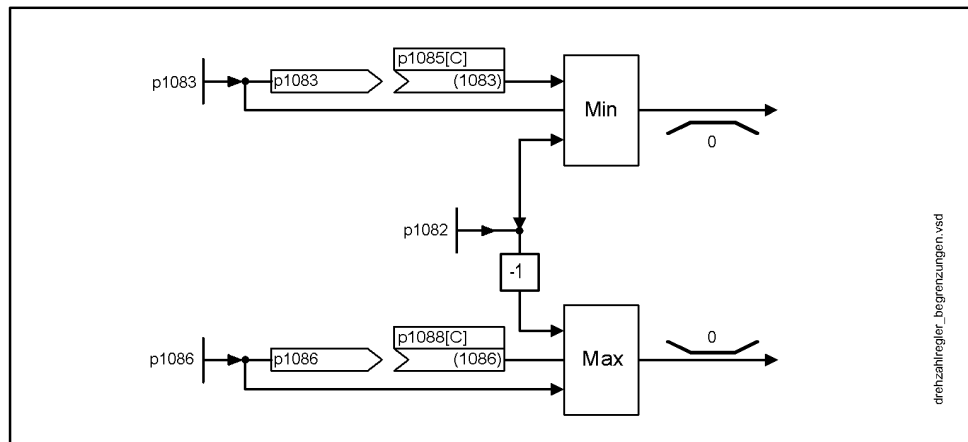


Fig. 3-1 Speed limits

3.1.2 Speed setpoint filter

The two speed setpoint filters are identical in structure and can be used as follows:

- Bandstop
- Low-pass 1st order (PT1) or
- Low-pass 2nd order (PT2)

Both filters are activated via parameter p1414.x. Parameters p1415 and p1421 are used to select the filter elements.

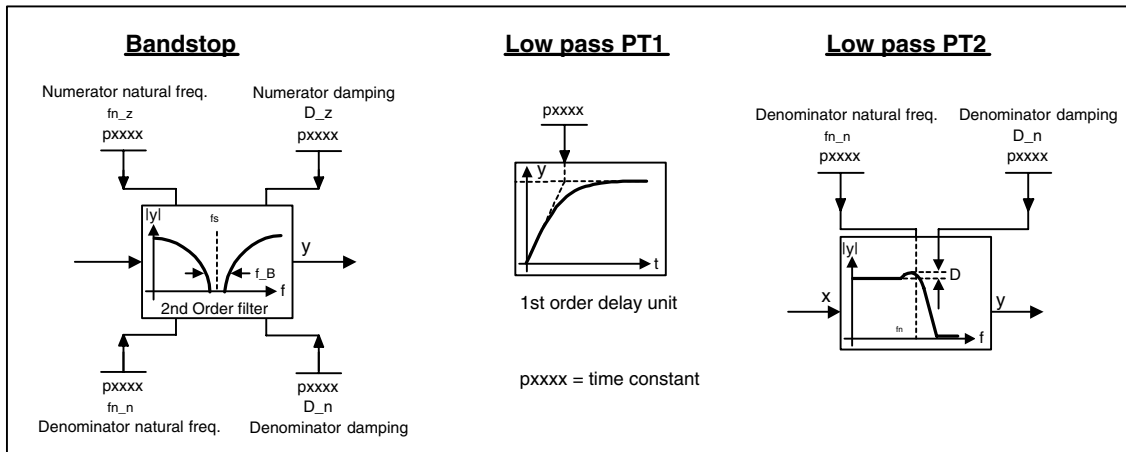


Fig. 3-2 Filter overview for speed setpoint filters

Parameter overview for speed setpoint filter (refer to the List Manual)

Adjustable parameters

- p1414[D] Speed setpoint filter activation
- p1415[D] Speed setpoint filter 1 type
- p1416[D] Speed setpoint filter 1 time constant
- p1417[D] Speed setpoint filter 1 denominator natural frequency
- p1418[D] Speed setpoint filter 1 denominator damping
- p1419[D] Speed setpoint filter 1 numerator natural frequency
- p1420[D] Speed setpoint filter 1 numerator damping
- p1421[D] Speed setpoint filter 2 type
- p1422[D] Speed setpoint filter 2 time constant
- p1423[D] Speed setpoint filter 2 denominator natural frequency
- p1424[D] Speed setpoint filter 2 denominator damping
- p1425[D] Speed setpoint filter 2 numerator natural frequency
- p1426[D] Speed setpoint filter 2 numerator damping

Function diagram overview (refer to the List Manual)

- 5020 Speed setpoint filter and speed pre-control

Parameterization

The “speed setpoint filter” parameter screen is selected via the following icon in the toolbar of the STARTER commissioning tool:

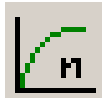


Fig. 3-3 STARTER icon for “speed setpoint filter”

3.1.3 Speed controller adaptation

Description

Two adaptation methods are available, namely free Kp_n adaptation and speed-dependent Kp_n/Tn_n adaptation.

Free Kp_n adaptation is also active in “operation without encoder” mode and is used in “operation with encoder” mode as an additional factor for speed-dependent Kp_n adaptation.

Speed-dependent Kp_n/Tn_n adaptation is only active in “operation with encoder” mode and also affects the Tn_n value.

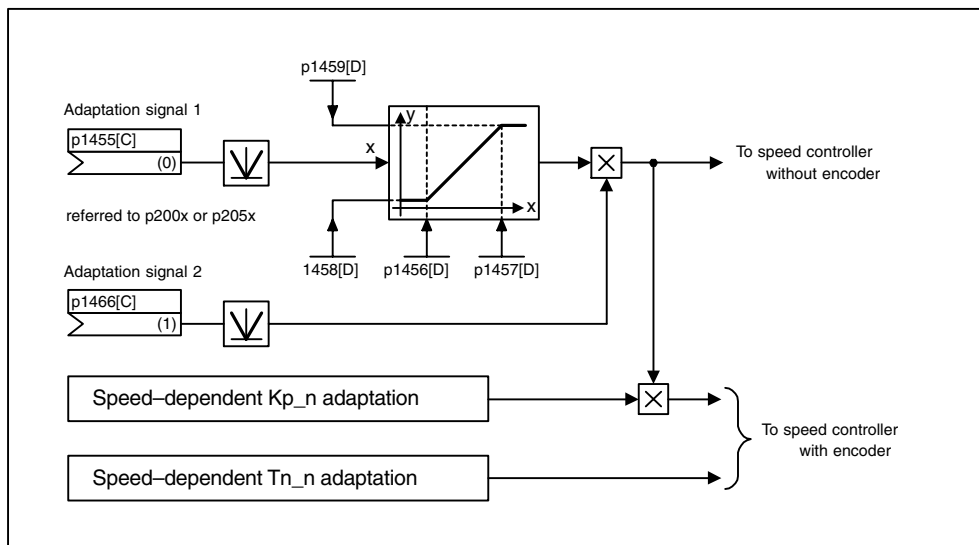


Fig. 3-4 Free Kp_n adaptation

Example of speed-dependent adaptation

Note

This type of adaptation is only active in “operation with encoder” mode.

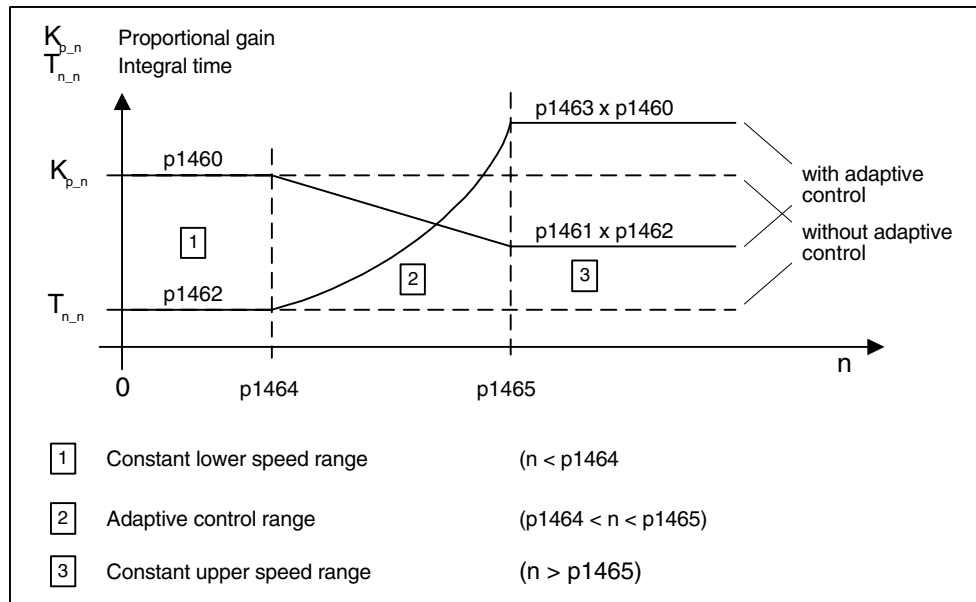


Fig. 3-5 Speed controller $K_{p,n}/T_{n,n}$ adaptation

Parameterization

The “speed controller” parameter screen is selected via the following icon in the toolbar of the STARTER commissioning tool:



Fig. 3-6 STARTER icon for “speed controller”

Parameter overview for speed controller adaptation (refer to the List Manual)

Free Kp_n adaptation

- p1455[0...n] CI: Speed controller P gain adaptation signal
- p1456[0...n] Speed controller P gain adaptation, lower starting point
- p1457[0...n] Speed controller P gain adaptation upper starting point
- p1458[0...n] Lower adaptation factor
- p1459[0...n] Upper adaptation factor

Speed-dependent Kp_n/Tn_n adaptation

- p1460[0...n] Lower adaptation speed P gain speed controller
- p1461[0...n] Upper adaptation speed P gain speed controller
- p1462[0...n] Speed controller integral action time, lower adaptation speed
- p1463[0...n] Speed controller integral action time, upper adaptation speed
- p1464[0...n] Lower adaptation speed speed controller
- p1465[0...n] Upper adaptation speed speed controller
- p1466[0...n] CI: Speed controller P-gain scaling

Function diagram overview (refer to the List Manual)

- 5050 Kp_n and Tn_n adaptation

3.1.4 Torque-controlled operation

Description

An operating mode switchover (p1300) can be carried out or a binector input (p1501) used to switch from speed control to torque control mode. All torque setpoints from the speed control system are rendered inactive. The setpoints for torque control mode are selected by parameterization.

Properties

- Switchover to torque control mode via:
 - Operating mode selection
 - Binector input
- Torque setpoint can be specified:
 - The torque setpoint source can be selected
 - The torque setpoint can be scaled
 - An additional torque setpoint can be entered
- Display of the overall torque

Commissioning torque control mode

1. Set torque control mode (p1300 = 23; p1501 = "1" signal)
2. Specify torque setpoint
 - Select source (p1511)
 - Scale setpoint (p1512)
 - Select supplementary setpoint (1513)

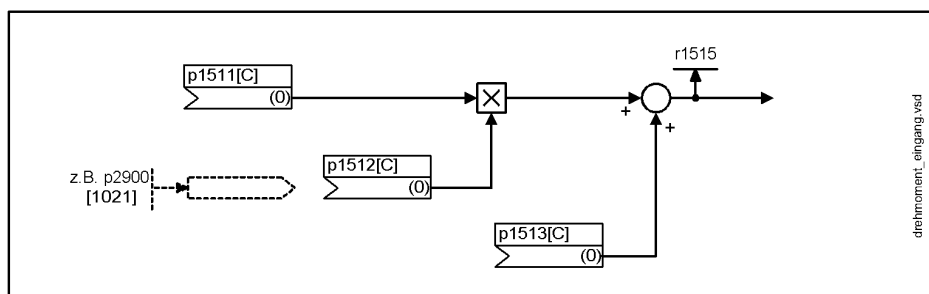


Fig. 3-7 Torque setpoint

3. Activate enable signals

OFF responses

- OFF1 and p1300 = 23
 - Reaction as for OFF2
- OFF1, p1501 = "1" signal and p1300 ≠ 23
 - No separate braking response; the braking response takes place by a drive that specifies the torque.
 - The pulses are suppressed when the brake application time (p1217) expires. Zero speed is detected if the actual speed drops below the threshold in p1226 or if the monitoring time (p1227) started when speed setpoint ≤ speed threshold (p1226) has expired.
 - Power-on disable is activated.
- OFF2
 - Instantaneous pulse suppression, the drive "coasts" to a standstill.
 - The motor brake (if parameterized) is closed immediately.
 - Power-on disable is activated.
- OFF3
 - Switch to speed-controlled operation
 - n_set=0 is input immediately to brake the drive along the OFF3 deceleration ramp (p1135).
 - When zero speed is detected, the motor brake (if parameterized) is closed.
 - The pulses are suppressed when the motor brake application time (p1217) has elapsed. Zero speed is detected if the actual speed drops below the threshold in p1226 or if the monitoring time (p1227) started when speed setpoint ≤ speed threshold (p1226) has expired.
 - Power-on disable is activated.

Function diagrams for torque-controlled operation (see List Manual)

- 5060 Torque setpoint, control mode switchover
- 5610 Torque limitation/reduction/interpolator

Signal overview (see List Manual)

- r1406.12 Torque control active

Parameterization

The “torque setpoint” parameter screen is selected via the following icon in the toolbar of the STARTER commissioning tool:



Fig. 3-8 STARTER icon for “torque setpoint”

Parameters for torque-controlled operation (see List Manual)

Adjustable parameters

- p1300 Open-loop/closed-loop control operating mode
- p1501[C] BI: Change over between closed-loop speed/torque control
- p1511[C] CI: Supplementary torque 1
- p1512[C] CI: Supplementary torque 1 scaling
- p1513[C] CI: Supplementary torque 2

Visualization parameters

- r1515 Supplementary torque total

3.1.5 Torque setpoint limitation

Description

The steps required for limiting the torque setpoint are as follows:

1. Define the torque setpoint and an additional torque setpoint
2. Generate torque limits

The torque setpoint can be limited to a maximum permissible value in all four quadrants. Different limits can be parameterized for motor and regenerative modes.

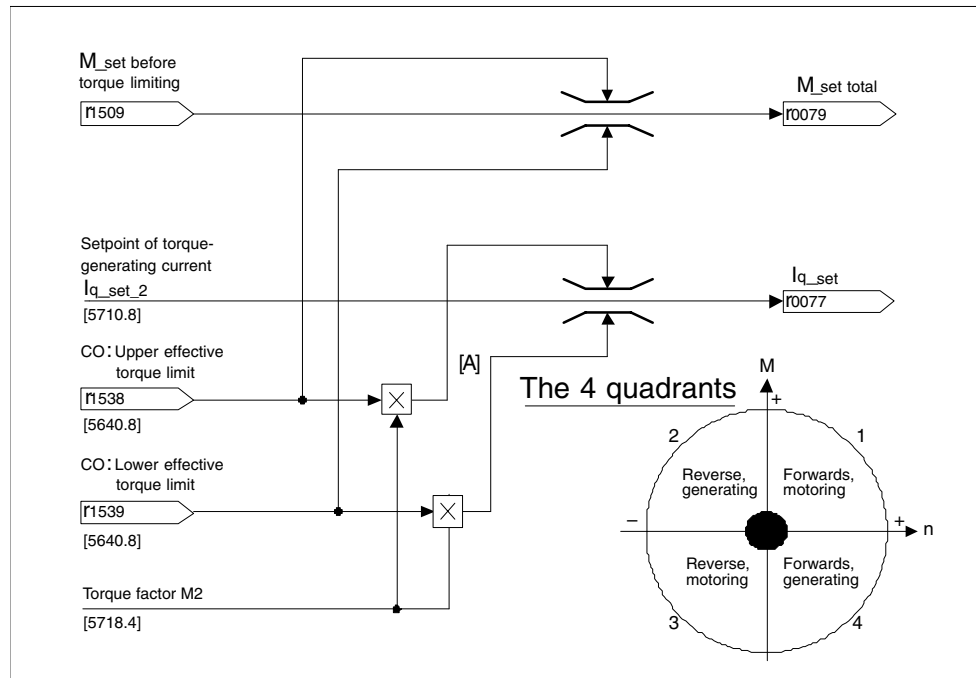


Fig. 3-9 Current/torque setpoint limiting

Note

This function is effective immediately without any settings. The user can also define further settings for limiting the torque.

Properties

The connector inputs of the function are initialized with fixed torque limits. If required, the torque limits can also be defined dynamically (during operation).

- A control bit can be used to select the torque limitation mode. The following alternatives are available:
 - Upper and lower torque limit
 - Motor and regenerative torque limit
- Additional power limitation configurable
 - Motor mode power limit
 - Regenerative mode power limit
- The following factors are monitored by the current controller and thus always apply in addition to torque limitation:
 - Stall power
 - Maximum torque-generating current
- Offset of the setting values also possible (see Fig. 3-10)
- The following torque limits are displayed via parameters:
 - Lowest of all upper torque limits with and without offset
 - Highest of all lower torque limits with and without offset

Fixed and variable torque limit settings

Table 3-1 Fixed and variable torque limit settings

Selection	Torque limitation mode			
Mode	Maximum upper or lower torque limits p1400.4 = 0		Maximum motor or regenerative mode torque limits p1400.4 = 1	
Fixed torque limit	Upper torque limit (as positive value)	p1520	Motor mode torque limit (as positive value)	p1520
	Lower torque limit (as negative value)	p1521	Regenerative mode torque limit (as negative value)	p1521
Source for variable torque limit	Upper torque limit	p1522	Motor mode torque limit	p1522
	Lower torque limit	p1523	Regenerative mode torque limit	p1523
Source for variable scaling factor of torque limit	Upper torque limit	p1528	Motor mode torque limit	p1528
	Lower torque limit	p1529	Regenerative mode torque limit	p1529
Torque offset for torque limit	Shifts the upper and lower torque limits together	p1532	Shifts the motor and regenerative mode torque limits together	p1532

Variants of torque limitation

The following variants are available:

1. No settings entered:

The application does not require any additional restrictions to the torque limits.

2. Fixed limits are required for the torque:

- The fixed upper and lower limits or alternatively the fixed motor and regenerative limits can be specified separately by different sources.

3. Dynamic limits are required for the torque:

- The dynamic upper and lower limit or, alternatively, the dynamic motor and regenerative limit can be specified separately by different sources.
- Parameters are used to select the source of the current limit.

4. A torque offset can be parameterized.

5. In addition, the power limits can be parameterized separately for motor and regenerative mode.

Notice

Negative values at r1534 or positive values at r1535 represent a minimum torque for the other torque directions and can cause the drives to rotate if no load torque is generated to counteract this (see List Manual SINAMICS S function diagram 5630).

Example: Torque limits with or without offset

The signals selected via p1522 and p1523 include the torque limits parameterized via p1520 and p1521.

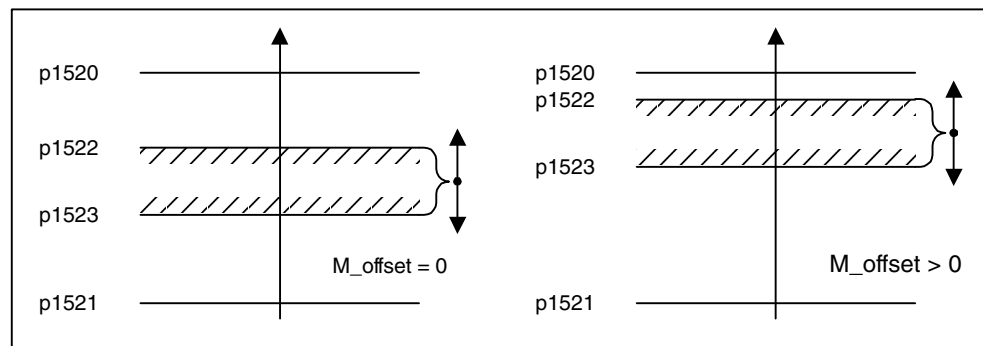


Fig. 3-10 Example: Torque limits with or without offset

Activating the torque limits

1. Use parameters to select the torque limitation source.
2. Use a control word to specify the torque limitation mode.
3. The following can also be carried out if necessary:
 - Select and activate additional limitations.
 - Set the torque offset.

Examples

- Travel to fixed stop (see Section 3.1.15)
- Tension control for continuous goods conveyors and winders

Function diagrams for torque setpoint limitation (see List Manual)

- 5610 Torque limitation/reduction/interpolator
- 5620 Motor/generator torque limit
- 5630 Upper/lower torque limit
- 5640 Mode changeover, power/current limiting

Parameterization

The “torque limit” parameter screen is selected via the following icon in the toolbar of the STARTER commissioning tool:



Fig. 3-11 STARTER icon for “torque limit”

Parameters for torque setpoint limitation (see List Manual)

- p0640[0...n] Current limit
- p1400[0...n] Speed control configuration
- r1508 CO: Torque setpoint before supplementary torque
- r1509 CO: Torque setpoint before torque limiting
- r1515 Supplementary torque total
- p1520[0...n] CO: Torque limit, upper/motoring
- p1521[0...n] CO: Torque limit, lower/regenerative
- p1522[C] CI: Torque limit, upper/motoring
- p1523[C] CI: Torque limit, lower/regenerative
- r1526 Upper torque limit of all torque limits without offset

- r1527 Lower torque limit all torque limits without offset
- p1528[0...n] CI: Torque limit, upper/motoring, scaling
- p1529[0...n] CI: Torque limit, lower/regenerating scaling
- p1530[0...n] Power limit, motor mode
- p1531[0...n] Power limit, regenerative mode
- p1532[0...n] Torque offset torque limit
- r1533 Maximum torque-generating current of all current limits
- r1534 CO: Torque limit, upper total
- r1535 CO: Torque limit, lower total
- r1536 Maximum motor-mode torque-generating current limit
- r1537 Minimum motor-mode torque-generating current limit
- r1538 CO: Upper effective torque limit
- r1539 CO: Lower effective torque limit

3.1.6 “Extended torque control” function module (k_T estimator)

Description

The function module “extended torque control” comprises two modules – the k_T estimator and the compensation of the voltage emulation error of the drive converter. This allows the torque accuracy to be increased.

Note

When this function module is activated, the maximum number of drives that can be controlled from a control unit is reduced by at least one drive.

Features

- k_T estimator (only for synchronous motors)
- Compensation of the voltage emulation error of the drive converter (p1952, p1953)
- Configuration via p1780

Commissioning via STARTER

The extended torque control can be activated via: Righthand mouse click on the drive → Properties → Function modules.

Parameter r0108.1 indicates whether it has been activated.

Description k_T estimator

The adaptation of the torque constants for synchronous motors is used to improve the absolute torque accuracy for the control (closed-loop) of synchronous motors. The magnetization of the permanent magnets varies as a result of production tolerances and temperature fluctuations and saturation effects. This function “ k_T estimator” adapts the torque constant k_T [Nm/A] in the control to the instantaneous magnetization. It only makes sense to use the k_T estimator in conjunction with the friction characteristic as the k_T estimator can only correct the inner motor torque. The frictional losses must be compensated from the friction characteristic using a supplementary torque.

The k_T estimator requires the most accurate values for the motor parameters as possible in order to achieve a high torque accuracy. Before using the k_T estimator, it is therefore necessary to carry-out a motor identification routine (p1909, p1910) with the k_T estimator activated; this determines the values for the stator resistance (p0350), leakage inductance (p0356) and voltage emulation errors (p1952, p1953). The cable resistance must be calculated before the motor identification and entered into p0352.

Formula to calculate the cable resistance:

$$R \text{ (cable resistance)} = \frac{\rho \text{ (specific resistance)} \times l \text{ (cable length)}}{A \text{ (cross section)}}$$

$$\rho_{\text{copper}} = 0.0178 \left[\frac{\Omega \times \text{mm}^2}{\text{m}} \right]$$

l = Cable length [m]

A = Cable cross-section [mm²]

The motor should be at room temperature when the identification routine is carried out. The compensation of the voltage emulation error must be activated (p1780.8 = 1).

A KTY sensor (p0601 = 2 or 3) should be used to sense the motor temperature (p0600).

The estimator requires the motor temperature in order to track/correct the temperature-dependent quantities. If a motor temperature sensor is not connected, then the accuracy is significantly restricted.

The k_T estimator is only activated above a specific speed (p1752). The terminal voltage of the drive converter always has small errors, caused by voltage drops across the power semiconductors etc. The lower the speed and therefore the output voltage, the greater the negative influence on the estimation as a result of low voltage errors. This is the reason that the estimation is de-activated below a specific speed. The estimated value is smoothed using time constant p1795. The correction value for the torque constant is displayed in r1797. By identifying the torque constant k_T using the rotating motor identification routine, the torque accuracy can be improved also below the speed threshold (1752).

The k_T estimator is activated using p1780.3 and the voltage compensation using p1780.8.

Overview of important parameters (refer to the List Manual)

- r0108.1 Function module – extended torque control active
- p1780.3 Selects motor model PEM k_T adaptation
- p1780.8 Compensation of the voltage emulation error in the drive converter

Motor/drive converter identification

- p0352 Cable resistance
- p1909 Motor data identification control word
- p1910 Activates motor data identification routine, stationary (standstill)

k_T estimator:

- p1752 Motor model, changeover speed operation with encoder
- p1795 Motor model PEM k_T adaptation smoothing time
- r1797 Motor model PEM k_T adaptation correction value

Compensation of the voltage emulation error of the drive converter:

- p1952 Voltage emulation error, final value
- p1953 Voltage emulation error, current offset

Function diagrams (refer to the List Manual)

- 7008 k_T estimator

3.1.7 Current controller

Properties

- PI controller for current control
- Four identical current setpoint filters
- Current and torque limitation
- Current controller adaptation
- Flux control

Closed-loop current control

No settings are required for operating the current controller. The controller can be optimized for special applications (see Section 3.1.12).

Current and torque limitation

The current and torque limitations are initialized when the system is commissioned for the first time and should be adjusted according to the application.

Current controller adaptation

The P gain of the current controller can be reduced (depending on the current) by means of current controller adaptation.

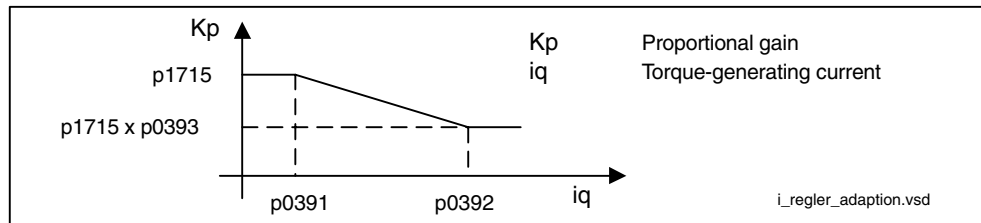


Fig. 3-12 Current controller adaptation

Flux controller (for induction motor)

The parameters for the flux controller are initialized when the system is commissioned for the first time and do not usually need to be adjusted.

Function diagrams for the current controller (see List Manual)

- 5710 Current setpoint filter
- 5714 Iq and Id controllers
- 5718 Interface to the Motor Module (gating signals, current actual values)
- 5722 Field current input, flux controller

Parameters for current controller (see List Manual)

Closed-loop current control

- p1701[0...n] Current controller reference model deadtime
- p1715[0...n] Current controller P gain
- p1717[0...n] Current controller integral time

Current and torque limitation

- p0323[0...n] Maximum motor current
- p0326[0...n] Stall torque correction factor
- p0640[0...n] Current limit
- p1520[0...n] CO: Torque limit, upper/motoring
- p1521[0...n] CO: Torque limit, lower/regenerative
- p1522[0...n] CI: Torque limit, upper/motoring
- p1523[0...n] CI: Torque limit, lower/regenerative
- p1524[0...n] CO: Torque limit, upper/motoring, scaling
- p1525[0...n] CO: Torque limit, lower/regenerating scaling
- p1528[0...n] CI: Torque limit, upper/motoring, scaling
- p1529[0...n] CI: Lower or regenerative torque limit scaling
- p1530[0...n] Power limit, motor mode
- p1531[0...n] Power limit, regenerative mode
- p1532[0...n] Torque offset torque limit

Visualization parameters

- r1526 Upper torque limit of all torque limits without offset
- r1527 Lower torque limit all torque limits without offset
- r1533 Maximum torque-generating current of all current limits
- r1534 CO: Torque limit, upper total
- r1535 CO: Torque limit, lower total
- r1536 Maximum motor-mode torque-generating current limit
- r1537 Maximum motor-mode torque-generating current limit
- r1538 CO: Upper effective torque limit
- r1539 CO: Upper effective torque limit

Current controller adaptation

- p0391[0...n] Current controller adaptation lower starting point
- p0392[0...n] Current controller adaptation upper starting point
- p0393[0...n] Current controller adaptation upper P gain
- p1590[0...n] Flux controller P gain
- p1592[0...n] Flux controller integral time

3.1.8 Current setpoint filter

Description

The four current setpoint filters connected in series can be parameterized as follows:

- Low-pass 2nd order (PT2): -40dB/Decade (type 1)
- General filter 2nd order (type 2)
Bandstop and lowpass with reduction are converted to the parameters of the general filter 2nd order via STARTER.
 - Bandstop
 - Low-pass with reduction by a constant value

The phase frequency curve is shown alongside the amplitude log frequency curve. A phase shift results in a control system delay and should be kept to a minimum.

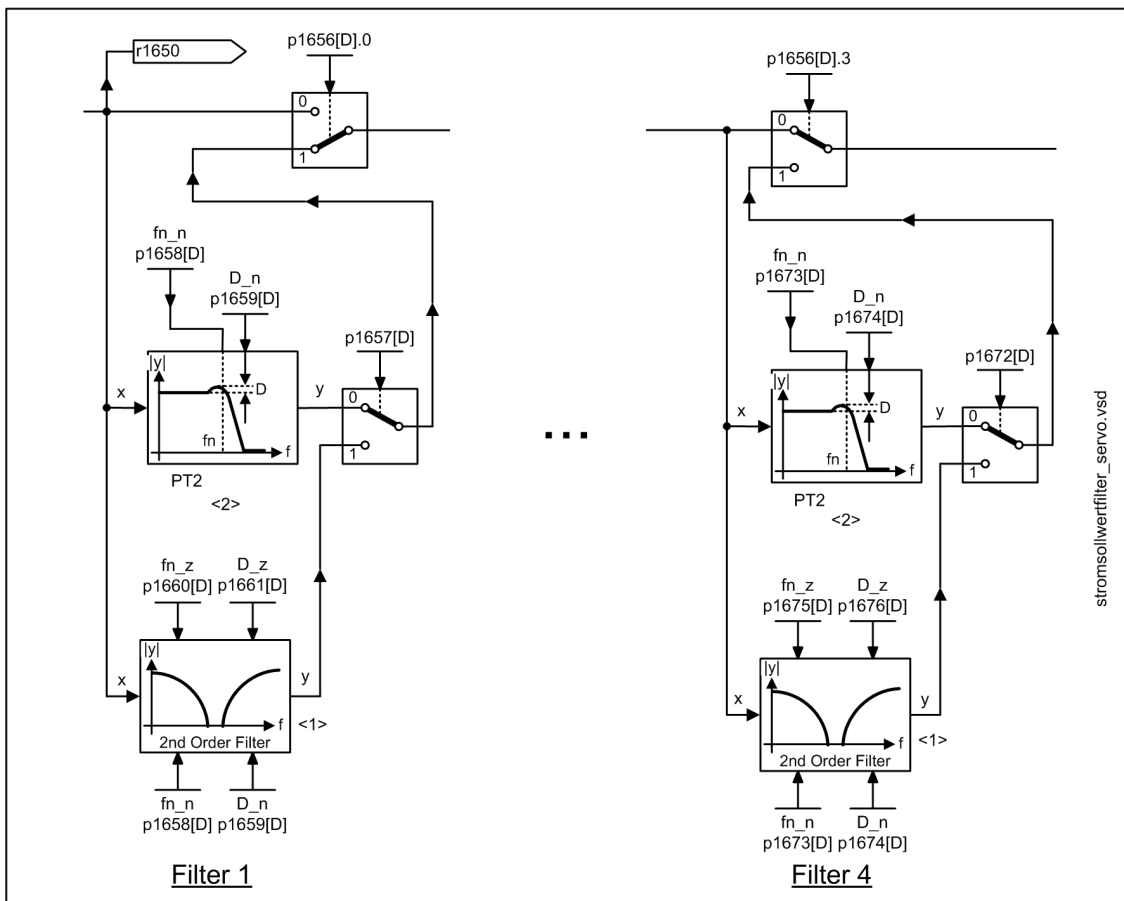


Fig. 3-13 Current setpoint filter

Low-pass 2nd order (PT2 filter)

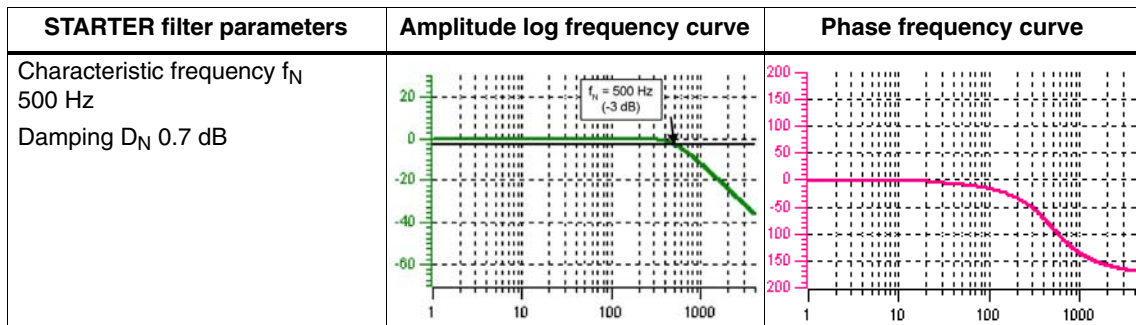
Transfer function:

$$H(s) = \frac{1}{\left(\frac{s}{2\pi f_N}\right)^2 + \frac{2D_N}{2\pi f_N} \cdot s + 1}$$

Denominator natural frequency f_N

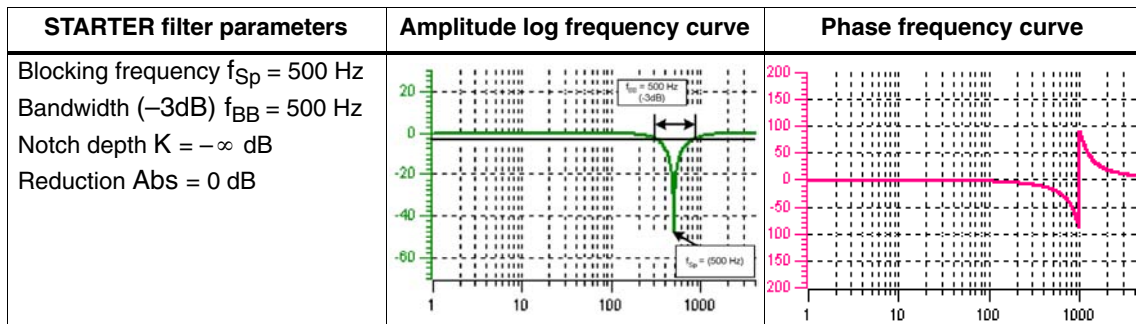
Denominator damping D_N

Table 3-2 Example of a PT2 filter



Band-stop with infinite notch depth

Table 3-3 Example of band-stop with infinite notch depth



Simplified conversion to parameters for general order filters:

Reduction or increase after the blocking frequency (Abs)

Infinite notch depth at the blocking frequency

- Numerator frequency $f_Z = f_{Sp}$
- Numerator damping $D_Z = 0$
- Denominator natural frequency $f_N = f_{Sp}$
- Denominator damping $D_N = \frac{f_{BB}}{2 \cdot f_{Sp}}$

Band-stop with defined notch depth

Table 3-4 Example of band-stop with defined notch depth

STARTER filter parameters	Amplitude log frequency curve	Phase frequency curve
Blocking frequency $f_{Sp} = 500$ Hz Bandwidth $f_{BB} = 500$ Hz Notch depth $K = -20$ dB Reduction Abs = 0 dB		

Simplified conversion to parameters for general order filters:

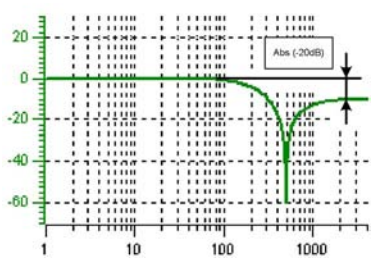
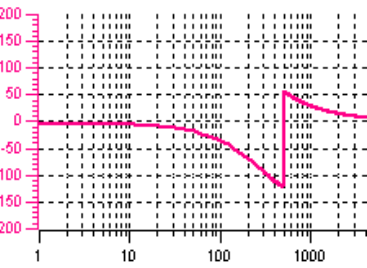
No reduction or increase after the blocking frequency

Defined notch at the blocking frequency K [dB] (e.g. -20 dB)

- Numerator frequency $f_Z = f_{Sp}$
- Numerator damping $D_Z = \frac{f_{BB}}{2 \cdot f_{Sp} \cdot 10^{\frac{K}{20}}}$
- Denominator natural frequency $f_N = f_{Sp}$
- Denominator damping $D_N = \frac{f_{BB}}{2 \cdot f_{Sp}}$

Band-stop with defined reduction

Table 3-5 Example of band-stop

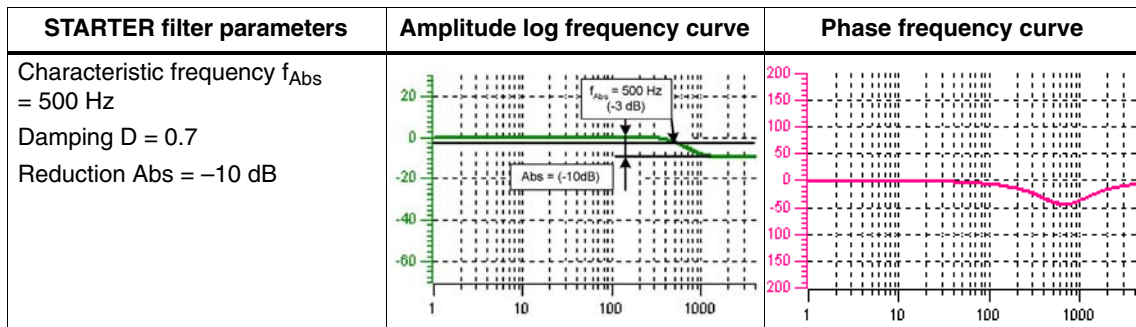
STARTER filter parameters	Amplitude log frequency curve	Phase frequency curve
Blocking frequency $f_{SP} = 500$ Hz Bandwidth $f_{BB} = 500$ Hz Notch depth $K = \text{infinite dB}$ Reduction $ABS = -10$ dB		

General conversion to parameters for general order filters:

- Numerator natural frequency $f_z = \frac{\omega_z}{2\pi} = f_{sp}$
- Numerator damping $D_z = 10^{\frac{K}{20}} \cdot \frac{1}{2} \cdot \sqrt{\left(1 - \frac{1}{10^{\frac{Abs}{20}}}\right)^2 + \frac{f_{BB}^2}{f_{Sp}^2 \cdot 10^{\frac{Abs}{10}}}}$
- Denominator natural frequency $f_N = \frac{\omega_N}{2\pi} = f_{sp} \cdot 10^{\frac{Abs}{40}}$
- Denominator damping $D_N = \frac{f_{BB}}{2 \cdot f_{Sp} \cdot 10^{\frac{Abs}{40}}}$

General low-pass with reduction

Table 3-6 Example of general low-pass with reduction



Conversion to parameters for general order filters

- Numerator natural frequency $f_z = f_{Abs}$ (start of reduction)
- Numerator damping $f_z = \frac{f_{Abs}}{10^{\frac{Abs}{40}}}$
- Denominator natural frequency f_N
- Denominator damping D_N

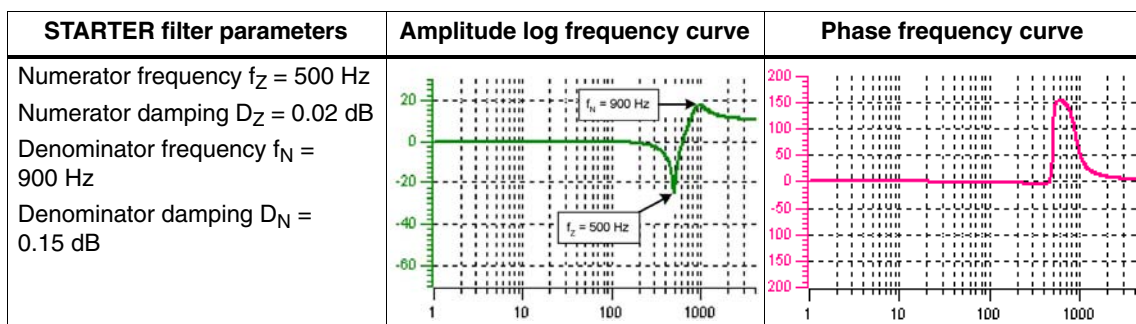
Transfer function general 2nd-order filter

$$H_{(s)} = \frac{\left(\frac{s}{2\pi f_z}\right)^2 + \frac{2D_z}{2\pi f_z} \cdot s + 1}{\left(\frac{s}{2\pi f_N}\right)^2 + \frac{2D_N}{2\pi f_N} \cdot s + 1}$$

$$s = j\omega = j \cdot 2\pi f$$

- Numerator natural frequency f_z
- Numerator damping D_z
- Denominator natural frequency f_N
- Denominator damping D_N

Table 3-7 Example of general 2nd-order filter



Parameterization

The “current setpoint filter” parameter screen is selected via the following icon in the toolbar of the STARTER commissioning tool:



Fig. 3-14 STARTER icon for “current setpoint filter”

Parameter overview (see List Manual)

- p1656 Activates current setpoint filter
- p1657 Current setpoint filter 1 type
- p1658 Current setpoint filter 1 denominator natural frequency
- p1659 Current setpoint filter 1 denominator damping
- p1660 Current setpoint filter 1 numerator natural frequency
- p1661 Current setpoint filter 1 numerator damping
- ...
- p1676 Current setpoint filter 4 numerator damping
- p1699 Filter data transfer

Function diagram overview (refer to the List Manual)

- 5710 Current setpoint filter

3.1.9 V/f Control for diagnostics

Description

With V/f control, the motor is operated with an open control loop and does not require speed control or actual current sensing, for example. Operation is possible with a small amount of motor data.

V/f control can be used to check the following:

- Motor Module
- Power cable between the Motor Module <—> motor
- Motor
- DRIVE-CLiQ cable between the Motor Module <—> motor
- Encoder and actual encoder value

The following motors can be operated with V/f control:

- Induction motors
- Synchronous motors

Caution

V/f control must only be used as a diagnostic function (e.g. to check that the motor encoder is functioning correctly).

Note

In V/f mode, the calculated actual speed value is always displayed in r0063. The speed of the encoder (if installed) is displayed in r0061. If an encoder is not installed, r0061 displays "0".

Note

The operation of synchronous motors with V/f control is allowed only at up to 25 % of the rated motor speed.

Structure of V/f control

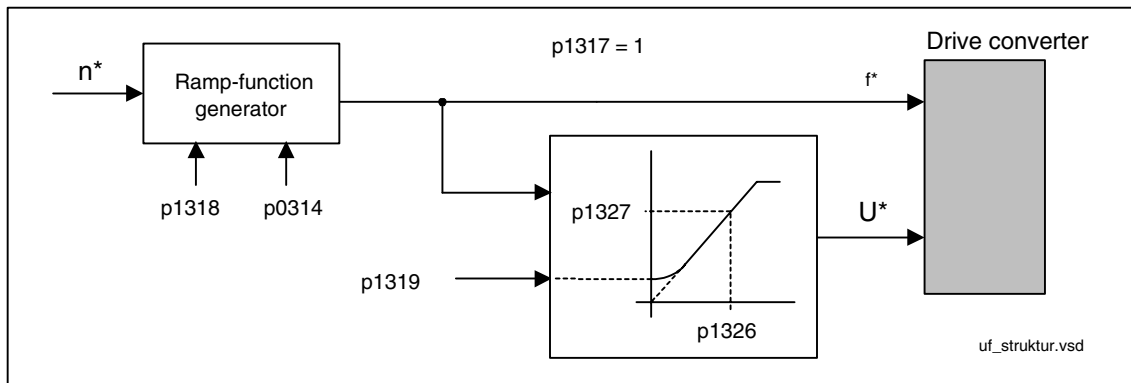


Fig. 3-15 Structure of V/f control

Prerequisites for V/f control

1. Initial commissioning has been performed:
The parameters for V/f control have been initialized with appropriate values.
2. Initial commissioning has not been performed:
The following relevant motor data must be checked and corrected:
 - r0313 Motor pole pair number, actual (or calculated)
 - p0314 Motor pole pair number
 - p1318 V/f control ramp-up/ramp-down time
 - p1319 V/f control voltage at zero frequency
 - p1326 V/f control programmable characteristic frequency 4
 - p1327 V/f control programmable characteristic voltage 4

V/f control can now be commissioned.

Note

With synchronous motors, V/f mode is normally only stable at low speeds. Higher speeds can induce vibrations.

Commissioning V/f control

1. Verify the preconditions for V/f control mode.
2. Set p0311 → rated motor speed
3. Set p1300 = 0 → activates the function
4. Activate the enable signals for operation
5. Specify the speed setpoint → evaluate the diagnostic function

V/f characteristic

The speed setpoint is converted to the frequency specification taking into account the number of pole pairs. The synchronous frequency associated with the speed setpoint is output (no slip compensation).

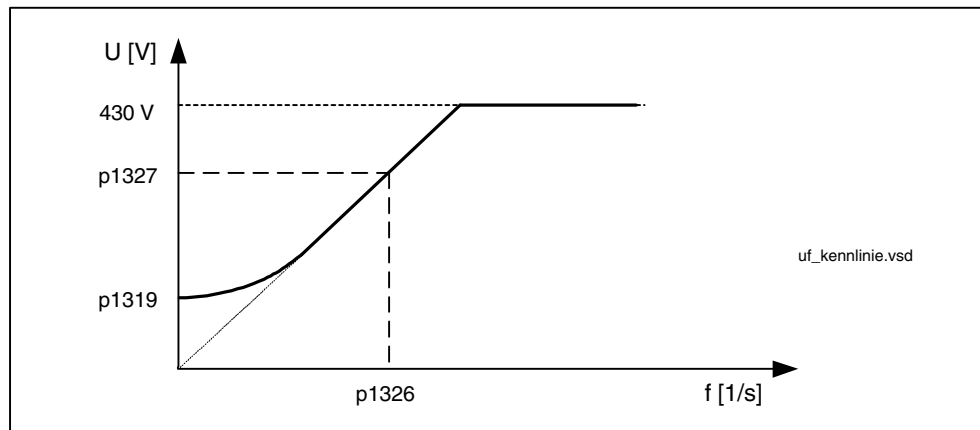


Fig. 3-16 V/f characteristic

Function diagrams for V/f control (see List Manual)

- 5300 V/f control for diagnostics

Parameters for V/f control (see List Manual)

Adjustable parameters

- p0304[0...n] Rated motor voltage
- p0310[0...n] Rated motor frequency
- p0311[0...n] Rated motor speed
- p0314[0...n] Number of motor pole pairs
- p0317[0...n] Motor voltage constant
- p0322[0...n] Maximum motor speed
- p0323[0...n] Maximum motor current
- p0640[0...n] Current limit
- p1082[0...n] Maximum speed
- p1300[0...n] Open-loop/closed-loop control operating mode
- p1318[0...n] V/f control ramp-up/ramp-down time
- p1319[0...n] V/f control voltage at zero frequency

Visualization parameters

- r0313[0...n] Number of motor pole pairs current (or calculated)

3.1.10 Sensorless operation (without an encoder)

Description

This allows operation without an encoder and mixed operation (with/without encoder). Encoderless operation with the motor model allows a higher dynamic response and greater stability than a standard drive with V/f control. Compared with drives with an encoder, however, speed accuracy is lower and the dynamic response and smooth running characteristics deteriorate.

Since the dynamic response in operation without an encoder is lower than in operation with an encoder, accelerating torque pre-control is implemented to improve the control dynamic performance.

It controls, knowing the drive torque, and taking into account the existing torque and current limits as well as the load moment of inertia (motor moment of inertia: $p0341 * p0342 + \text{load torque: } p1498$) the required torque for a demanded speed dynamic performance optimized from a time perspective.

For torque pre-control, a torque smoothing time can be parameterized via p1517. The speed controller must be optimized for operation without an encoder via p1470 (P gain) and p1472 (integral time) due to the reduced dynamic response.

At low speeds during operation without an encoder, the actual speed value, orientation, and the actual flux can no longer be calculated due to the accuracy of the measured values and the sensitivity of the parameters in this procedure.

For this reason, the system switches to current/frequency control.

The switchover threshold is parameterized via p1755 and the hysteresis via p1756.

To accommodate a high load torque in open-loop control, the motor current can be increased via p1612.

To do so, the drive torque (e.g. friction torque) must be known or estimated. An additional reserve of approx. 20 % should also be added. In synchronous motors, the torque is converted to the current via the motor torque constant (p0316). In the lower speed range, the required current cannot be measured directly on the Motor Module. The default setting is 50 % (synchronous motor) or 80 % (induction motors) of the rated motor current (p0305). When parameterizing the motor current (p1612), you must take into account the thermal motor load.

Note

Sensorless operation (without an encoder) is not permitted for vertical axes or similar. Sensorless operation is also not suitable for a higher-level closed-loop position control.

The start behavior of synchronous motors from standstill can be improved further by parameterizing the pole position identification (p1982 = 1).

Behavior once pulses have been canceled

Once the pulses have been canceled in operation without an encoder, the current actual speed value of the motor can no longer be calculated. Once the pulses are enabled again, the system must search for the actual speed value.

p1400.11 can be used to parameterize whether the search is to begin with the speed setpoint (p1400.11 = 1) or with speed = 0.0 (p1400.11 = 0).

Under normal circumstances, p1400.11 = 0 because the motor is usually started from standstill.

If the motor is rotating faster than the changeover speed p1755 when the pulses are enabled, p1400.11 = 1 must be set.

If the motor is rotating and the start value for the search is as of the setpoint (p1400.11 = 1), the speed setpoint must be in the same direction as the actual speed before the pulses can be enabled. A large discrepancy between the actual and setpoint speed can cause a malfunction.

**Warning**

Once the pulses have been canceled, no information about the motor speed is available. The computed actual speed value is then set to zero, which means that all actual speed value messages and output signals are irrelevant.

Switchover between closed-loop/open-loop operation and operation with/without encoder

Operation without an encoder is activated via parameter setting $p1300 = 20$.

If $p1300 = 20$ or $p1404 = 0$, operation without an encoder is active across the entire speed range. If the speed value is less than the changeover speed $p1755$, the motor is operated in accordance with the current/frequency.

During operation with an encoder, a switchover can be made to operation without an encoder when the speed threshold $p1404$ is exceeded. If $p1404 > 0$ and $p1404 < p1755$, a switchover is not made to operation without an encoder until the speed exceeds $p1755$.

Operation without an encoder is displayed in parameter $r1407.1$.

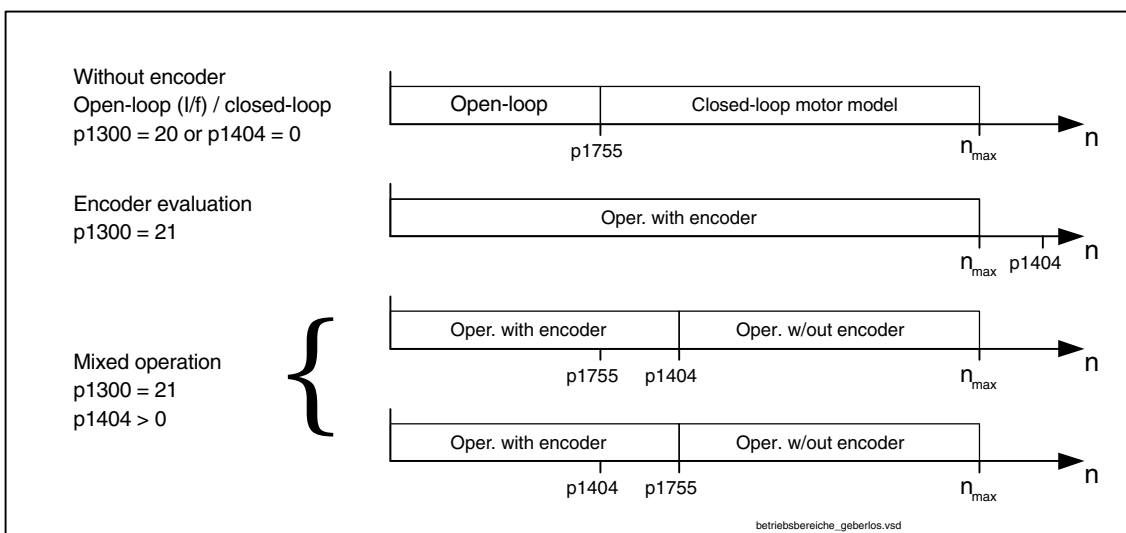


Fig. 3-17 Operation switchovers

Note

In closed-loop control operating mode “Speed controller without encoder”, a rotor position encoder is not required. Since a temperature monitor is not usually connected in this case either, this must be parameterized via $p0600 = 0$ (no sensor).

Series reactor

When special high-speed motors or other low-leakage induction motors are used, a series reactor may be required to ensure that the current controller remains stable. The series reactor can be integrated via $p0353$.

Commissioning/optimization

1. Estimate the motor current p1612 on the basis of the mechanical conditions ($I = M/kt$).
2. Set Kn (p1470) and Tn (p1472) above l/f operation ($> p1755$). The load moment of inertia should be set to zero here (p1498 = 0), since this deactivates part of the torque pre-control.
3. Determine the load moment of inertia in the speed range above l/f operation ($> p1755$) by setting p1498 via a ramp response (e.g. ramp time 100 ms) and assessing the current (r0077) and model speed (r0063).

Parameter overview (see List Manual)

- p0341 Motor moment of inertia
- p0342 Ratio between the total moment of inertia and that of the motor
- p0353 Motor series inductance
- p0600 Motor temperature sensor for monitoring
- p1300 Open-loop/closed-loop control operating mode
- p1400.11 Speed control configuration; sensorless operation actual speed value start value
- p1404 Sensorless operation changeover speed
- r1407.1 CO/BO: Status word speed controller; sensorless operation active
- p1470 Speed controller sensorless operation P-gain
- p1472 Speed controller sensorless operation integral-action time
- p1498 Load moment of inertia
- p1517 Accelerating torque smoothing time constant
- p1612 Current setpoint, open-loop control, sensorless
- p1755 Motor model without encoder, changeover speed
- p1756 Motor model changeover speed hysteresis

Function diagram overview (refer to the List Manual)

- 5050 Kp_n/Tn_n adaptation
- 5060 Torque setpoint, control mode switchover
- 5210 Speed controller

3.1.11 Motor data identification

Description

The motor data identification (MotID) is used as tool to determine the motor data, e.g. of third-party motors and can help to improve the torque accuracy (k_T estimator). The drive system must have been commissioned for the first time as basis for using MotID. To do this, either the electrical motor data (motor data sheet) or the rating plate data must be entered and the calculation of the motor/control parameters (p0340) must have been completed.

Commissioning involves the following steps:

- Enter the motor data or the rating plate data and the encoder data
- Complete calculation of the motor and control data as starting value for the MotID (p0340 = 3, if motor data, p0340 = 1, if rating plate data were entered)
- Carry-out a static measurement (p1910)
- For synchronous motors: Carry-out an angular commutation calibration (p1990) and if required, fine synchronization (refer to r1992)
- Carry-out a rotating measurement (p1960)

Before starting the rotating measurement, the speed controller setting should be checked and optimized (p1460, p1462 and p1470, p1472).

It is preferable if the rotating MotID is carried-out with the motor de-coupled from the mechanical system. This therefore means that only the motor moment of inertia is determined. The total moment of inertia with mechanical system can be subsequently identified with p1959 = 4 and p1960 = 1. The stress on the mechanical system can be reduced by parameterizing the ramp-up time (p1958) and/or using a speed limit (p1959.14/p1959.15) or using the current and speed limit. The higher the selected ramp-up time, the less accurate the moment of inertia determined.

The enable signals OFF1, OFF2, OFF3 and "enable operation" remain effective and can be interrupt the motor identification routine.

If there is an extended setpoint channel (r0108.08 = 1), parameters p1959.14 = 0 and p1959.15 = 0 and a direction of rotation limit (p1110 or p1111) is active there, then this is observed at the instant of the start via p1960. For p1958 = -1, the ramp-up and ramp-down time of the setpoint channel (p1120 and p1121) are also used for the MotID.

Note

If a ramp-up/ramp-down time or one direction of rotation limit is activated, parts of the motor data identification routine cannot be carried-out. For other parts of the motor data identification routine, the accuracy of the results is diminished because a ramp-up/ramp-down time is selected. If possible, p1958 should be 0 and no direction of rotation limit selected (p1959.14 = 1 and p1959.15 = 1).

**Danger**

The stationary MotID can result in slight movement of up to 210 degrees electrical.

For the rotating motor data identification routine, motor motion is initiated, which can reach the maximum speed (p1082) and the motor torque corresponding to the maximum current (p0640).

The rotating measurement should be carried-out with a motor running at no load (de-coupled from the mechanical system) in order to prevent damage/destruction to the load or be influenced by the load. If the motor cannot be de-coupled from the mechanical system, then the stress on the mechanical system can be reduced by parameterizing the ramp-up time (p1958) and/or using a speed limit (p1959.14/ p1959.15) or using the current and speed limit.

If there is a mechanical distance limit, we recommend that the rotating measurement is not carried-out.

The EMERGENCY SWITCHING-OFF functions must be completely functional when commissioning the system.

All of the relevant safety regulations must be carefully observed in order to exclude any danger for man and machine.

Motor data

Motor data input requires the following parameters:

Table 3-8 Motor data

Induction motor	Permanent-magnet synchronous motor
<ul style="list-style-type: none"> • p0304 rated motor voltage • p0305 rated motor current • p0307 rated motor power • p0308 rated motor power factor • p0310 rated motor frequency • p0311 rated motor speed • p0320 rated motor magnetizing current • p0322 maximum motor speed • p0350 motor stator resistance, cold • p0353 motor series inductance • p0354 motor rotor resistance, cold • p0356 motor stator leakage inductance • p0358 motor rotor leakage inductance • p0360 motor magnetizing inductance • p0400ff encoder data 	<ul style="list-style-type: none"> • p0305 rated motor current • p0311 rated motor speed • p0314 motor pole pair number • p0316 motor torque constant • p0322 maximum motor speed • p0323 maximum motor current • p0341 motor moment of inertia • p0350 motor stator resistance, cold • p0353 motor series inductance • p0356 motor stator leakage inductance • p0400ff encoder data

Type plate data

Rating plate data input requires the following parameters:

Table 3-9 Type plate data

Induction motor	Permanent-magnet synchronous motor
<ul style="list-style-type: none"> • p0304 rated voltage • p0305 rated current • p0307 rated power • p0308 rated power factor (cos φ) • p0310 rated frequency • p0311 rated speed • p0322 maximum motor speed • p0353 motor series inductance • p0400ff encoder data 	<ul style="list-style-type: none"> • p0304 rated voltage • p0305 rated current • p0307 rated power (alternative p0316) • p0311 rated speed • p0314 motor pole pair number or p0315 motor pole pair width • p0322 maximum motor speed • p0323 maximum motor current • p0353 motor series inductance • p0400ff encoder data

Since the type plate data contains the initialization values for identification, you must ensure that it is entered correctly and consistently to enable the above data to be determined.

Parameters to control the MotID

The following parameters influence the MotID:

Table 3-10 Parameters for control

Static measurement (motor data identification)	Rotating measurement
<ul style="list-style-type: none"> • p0640 current limit • p1215 motor holding brake configuration • p1909 motor data identification control word • p1910 motor data identification, stationary • p1959.14/.15 clockwise/counter-clockwise direction or rotation permitted 	<ul style="list-style-type: none"> • p0640 current limit • p1082 maximum speed • p1958 motor data identification ramp-up/ramp-down time • p1959 rotating measurement configuration • p1960 rotating measurement selection
<p>Note: If a brake is being used and is operational (p1215 = 1, 3), then the stationary measurement with closed brake is carried-out. If possible (e.g. no hanging/suspended axis), we recommend that the brake is opened before the MotID (p1215 = 2). This also means that the encoder size can be adjusted and the angular commutation calibrated.</p>	

Induction motor

The data are identified in the gamma equivalent circuit diagram and displayed in r19xx. The motor parameters p0350, p0354, p0356, p0358 and p0360 taken from the MotID refer to the T equivalent circuit diagram of the induction machine and cannot be directly compared. This is the reason that an r parameter is listed in the table, which displays the parameterized motor parameters in the gamma equivalent circuit diagram.

Table 3-11 Data determined using p1910 for induction motors (**stationary measurement**)

Determined data (gamma)	Data that are accepted (p1910 = 1)
r1912 identified stator resistance	p0350 motor stator resistance, cold + p0352 cable resistance
r1913 rotor time constant identified	r0384 motor rotor time constant/damping time constant, d axis
r1915 stator inductance identified	–
r1925 threshold voltage identified	–
r1927 rotor resistance identified	r0374 motor resistance cold (gamma) p0354
r1932 d inductance	r0377 motor leakage inductance, total (gamma) p0353 motor series inductance p0356 motor stator leakage inductance p0358 motor rotor leakage inductance p1715 current controller P gain p1717 current controller integral action time
r1934 q inductance identified	–
r1936 magnetizing inductance identified	r0382 motor magnetizing inductance transformed (gamma) p0360 motor magnetizing inductance p1590 flux controller P gain p1592 flux controller integral action time
r1973 encoder pulse number identified	–
Note: The encoder pulse number is only determined with a very high degree of inaccuracy (p0407/p0408) and is only suitable for making rough checks. The sign is negative if inversion is required (p0410.0).	
–	p0410 encoder inversion actual value
Note: If the encoder inversion is changed using MotID, fault F07993 is output, which refers to a possible change in the direction of rotation and can only be acknowledged by p1910 = –2.	

Table 3-12 Data determined using p1960 for induction motors (**rotating measurement**)

Determined data (gamma)	Data that are accepted (p1960 = 1)
r1934 q inductance identified	–
r1935 q inductance identification current	
Note: The q inductance characteristic can be used as basis to manually determine the data for the current controller adaptation (p0391, p0392 and p0393).	
r1936 magnetizing inductance identified	r0382 motor magnetizing inductance transformed (gamma) p0360 motor magnetizing inductance p1590 flux controller P gain p1592 flux controller integral action time
r1948 magnetizing current identified	p0320 rated motor magnetizing current
r1962 saturation characteristic magnetizing current identified	–
r1963 saturation characteristic stator inductance identified	–
Note: The magnetic design of the motor can be identified from the saturation characteristic.	
r1969 moment of inertia identified	p0341 motor moment of inertia * p0342 ratio between the total moment of inertia and that of the motor + p1498 load moment of inertia
r1973 encoder pulse number identified	–
Note: The encoder pulse number is only determined with a very high degree of inaccuracy (p0407/p0408) and is only suitable for making rough checks. The sign is negative if inversion is required (p0410.0).	

Synchronous motor

Table 3-13 Data determined using p1910 for synchronous motors (**stationary measurement**)

Determined data	Data that are accepted (p1910 = 1)
r1912 stator resistance identified	p0350 motor stator resistance, cold + p0352 cable resistance
r1925 threshold voltage identified	–
r1932 d inductance	p0356 motor stator leakage inductance + p0353 motor series inductance p1715 current controller P gain p1717 current controller integral action time
r1934 q inductance identified	–
r1950 voltage emulation error, voltage values	p1952 voltage emulation error, final value
r1951 voltage emulation error, current values	p1953 voltage emulation error, current offset
Note regarding r1950 to p1953: Active when the function module “extended torque control” is activated and activated compensation of the voltage emulation error (p1780.8 = 1).	
r1973 encoder pulse number identified	–
Note: The encoder pulse number is only determined with a very high degree of inaccuracy (p0407/p0408) and is only suitable for making rough checks. The sign is negative if inversion is required (p0410.0).	
r1984 pole position identification angular difference	p0431 angular commutation offset
Note: r1984 indicates the difference of the angular commutation offset before being transferred into p0431.	
–	p0410 encoder inversion actual value
Note: If the encoder inversion is changed using MotID, fault F07993 is output, which refers to a possible change in the direction of rotation and can only be acknowledged by p1910 = –2.	

Table 3-14 Data determined using p1960 for synchronous motors (**rotating measurement**)

Determined data	Data that are accepted (p1960 = 1)
r1934 q inductance identified	–
r1935 q inductance identification current	
Note: The q inductance characteristic can be used as basis to manually determine the data for the current controller adaptation (p0391, p0392 and p0393).	
r1937 torque constant identified	p0316 motor torque constant
r1938 voltage constant identified	p0317 motor voltage constant
r1939 reluctance torque constant identified	p0328 motor reluctance torque constant
r1947 optimum load angle identified	p0327 optimum motor load angle
r1969 moment of inertia identified	p0341 motor moment of inertia * p0342 ratio between the total moment of inertia and that of the motor + p1498 load moment of inertia
r1973 encoder pulse number identified	–
Note: The encoder pulse number is only determined with a very high degree of inaccuracy (p0407/p0408) and is only suitable for making rough checks. The sign is negative if inversion is required (p0410.0).	
r1984 pole position identification angular difference	p0431 angular commutation offset
Note: r1984 indicates the difference of the angular commutation offset before being transferred into p0431.	

For linear motors (p0300 = 4xx), p1959 is pre-set so that only the q inductance, the angular commutation offset and the high inertia mass are measured (p1959.05 = 1 and p1959.10 = 1), as generally the travel limits do not permit longer traversing distances in one direction.

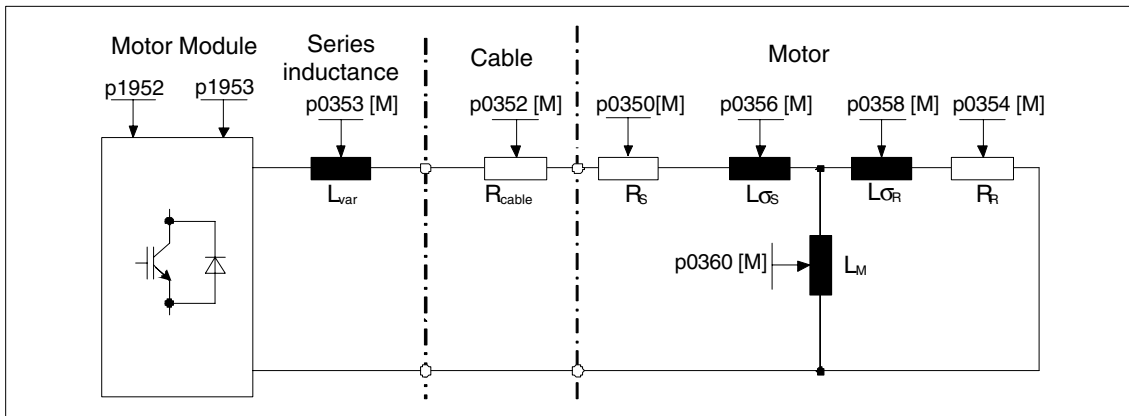


Fig. 3-18 Equivalent circuit diagram for induction motor and cable

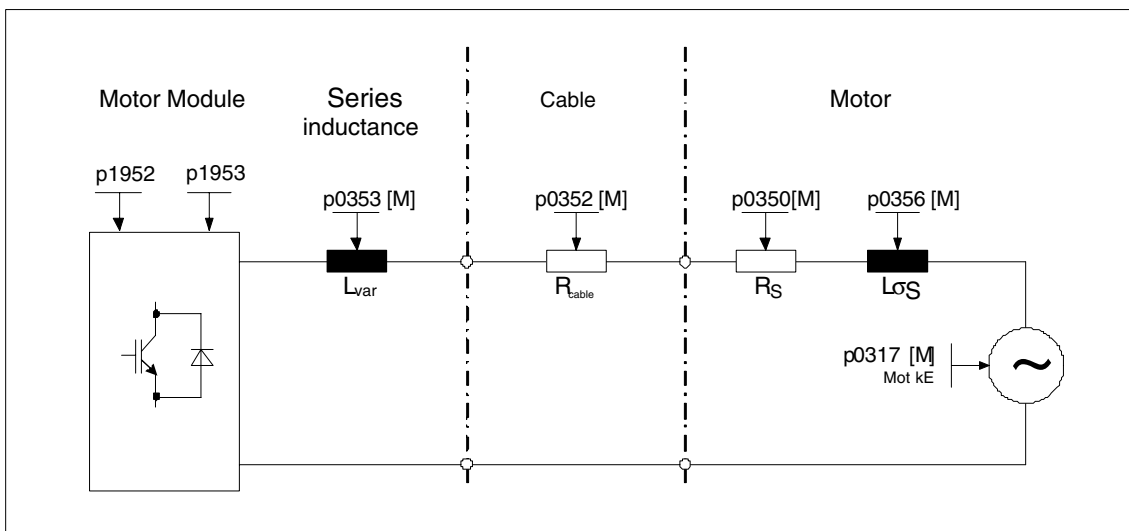


Fig. 3-19 Equivalent circuit diagram for synchronous motor and cable

Overview of important parameters (refer to the List Manual)

- r0047 Status identification
- Standstill measurement
- p1909 Motor data identification control word
 - p1910 Motor data identification routine, stationary (standstill)
- Rotating measurement
- p1958 Motor data identification ramp-up/ramp-down times
 - p1959 Rotating measurement configuration
 - p1960 Rotating measurement selection

3.1.12 Optimizing the current and speed controller

General information



Caution

Controller optimization may only be performed by skilled personnel with a knowledge of control engineering.

The following tools are available for optimizing the controllers:

- “Function generator” in STARTER
- “Trace” in STARTER
- “Measuring function” in STARTER
- CU320 measuring sockets

Optimizing the current controller

The current controller is initialized when the system is commissioned for the first time and is adequately optimized for most applications.

Optimizing the speed controller

The speed controller is set in accordance with the motor moment of inertia when the motor is configured for the first time. The calculated proportional gain is set to approximately 30 % of the maximum possible gain in order to minimize vibrations when the controller is mounted on the mechanics of the machine for the first time.

The integral time of the speed controller is always preset to 10 ms.

- The following optimization measures are necessary in order to achieve the full dynamic response:
 - Increase the proportional gain Kp_n (p1460)
 - Change the integral action time Tn_n (p1462)

Example of measuring the speed controller frequency response

By measuring the speed controller frequency response and the control system, critical resonance frequencies can, if necessary, be determined at the stability limit of the speed control loop and dampened using one or more current setpoint filters. This normally enables the proportional gain to be increased (e.g. $Kp_n = 3 \cdot$ default value).

After the Kp_n value has been set, the ideal integral action time Tn_n (e.g. reduced from 10 ms to 5 ms) can be determined.

Example of speed setpoint step change

A rectangular step change can be applied to the speed setpoint via the speed setpoint step change measuring function. The measuring function has preselected the measurement for the speed setpoint and the torque-generating current.

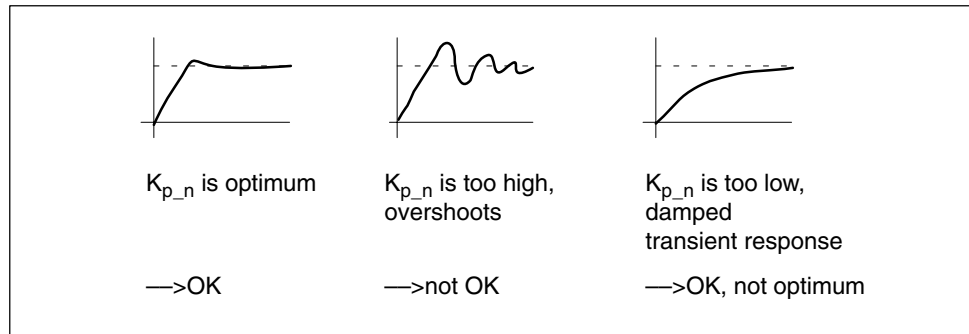


Fig. 3-20 Setting the proportional gain K_p

Parameter overview

See section “Speed controller”.

3.1.13 Pole position identification

Description

For synchronous motors, the pole position identification determines its electrical pole position, that is required for the field-oriented control. Generally, the electrical pole position is provided from a mechanically adjusted encoder with absolute information. In this case, pole position identification is not required. For the following encoder properties, pole position identification is not required:

- Absolute encoder (e.g. EnDat)
- Encoder with C/D track and pole pair number ≤ 8
- Hall sensor
- Resolver with a multiple integer ratio between the motor pole pair number and the encoder pole pair number
- Incremental encoder with a multiple integer ratio between the motor pole pair number and the encoder pulse number

The pole position identification is used for:

- Determining the pole position (p1982 = 1)
- Determining the angular commutation offset during commissioning (p1990 = 1)
- Plausibility check for encoders with absolute information (p1982 = 2)

**Warning**

With non-braked motors above the specified current, the measurement can cause the motor to rotate or move.

The degree of movement depends on the specified current intensity and the moment of inertia of the motor and load.

Notes regarding pole position identification

The relevant technique can be selected using parameter P1980. The following techniques are available for a pole position identification routine:

- Saturation-based 1st+ 2nd harmonics (p1980 = 0)
- Saturation-based 1st harmonics (p1980 = 1)
- Saturation-based, two-stage (p1980 = 4)
- Saturation-based (p1980 = 10)

The following limitations/constraints apply for the saturation-based motion technique:

- This technique can be used for both braked and non-braked motors.
- It can only be used for a speed setpoint = 0 or from standstill.
- The specified current magnitudes (p0325, p0329) must be sufficient to provide a significant measuring result.
- For motors without iron, the pole position cannot be identified using the saturation-based technique.
- For 1FN3 motors, no traversing with the 2nd harmonic should take place (p1980 = 0, 4).
- With 1FK7 motors, two-stage procedures must not be used (p1980 = 4). The value in p0329, which is set automatically, must not be reduced.

For the motion-based technique, the following constraints apply:

- The motor must be free to move and it may not be subject to external forces (no hanging/suspended axes)
- It can only be used for a speed setpoint = 0 or from standstill.
- If there is a motor brake, then this must be open (p1215 = 2).
- The specified current magnitude (p1993) must move the motor by a sufficient amount.



Warning

Before using the pole position identification routine, the control sense of the speed control loop must be corrected (p0410.0).

For linear motors, refer to the Commissioning Manual.

For rotating motors, in sensorless operation with a small positive speed setpoint (e.g. 10 RPM), the speed actual value (r0061) and the speed setpoint (r1438) must have the same sign.

Pole position determination with zero marks

The pole position identification routine provides coarse synchronization. If zero marks exist, the pole position can be automatically compared with the zero mark position once the zero mark(s) have been passed (fine synchronization). The zero mark position must be either mechanically or electrically (p0431) calibrated. If the encoder system permits this, then we recommend fine synchronization (p0404.15 = 1). This is because it avoids measurement spread and allows the determined pole position to be additionally checked.

Suitable zero marks are:

- One zero mark in the complete traversing range
- Equidistant zero marks whose relevant position to the commutation are identical
- Distance-coded zero marks

Determining a suitable technique for the pole position identification routine

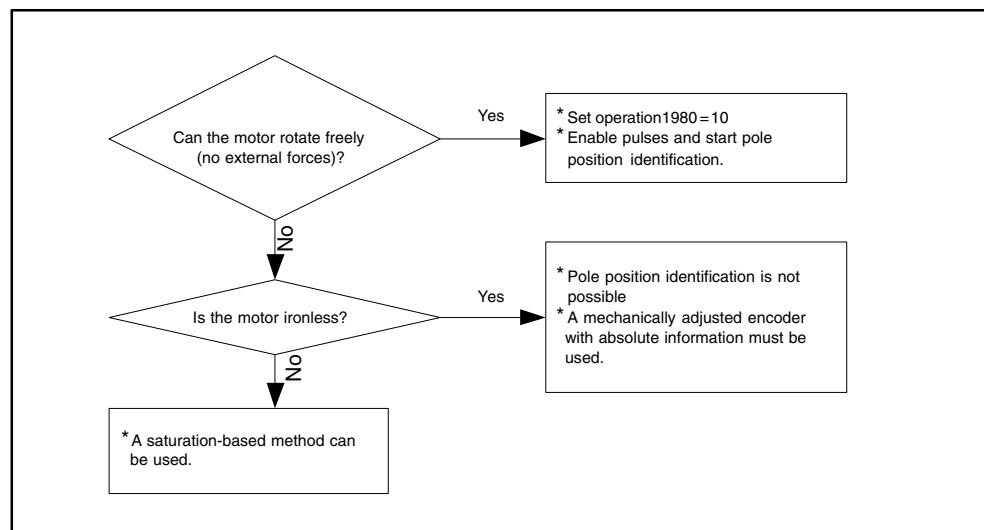


Fig. 3-21 Selecting the appropriate technique

Parameters for pole position identification

- p0325[0...n] Motor pole position identification current 1st phase
- p0329[0...n] Motor pole position identification current
- p0404.15 Commutation with zero mark
- p0431 Commutation angle offset
- p1980[0...n] Pole position identification procedure
- p1981[0...n] Pole position identification maximum movement
- p1982[0...n] Pole position identification selection
- p1983 Pole position identification test
- r1984 Pole position identification angle difference
- r1985 Pole position identification saturation curve
- r1987 Pole position identification trigger curve
- p1990 Pole position identification commutation angle offset commissioning
- r1992 Pole position identification diagnostics
- p1993 Pole position identification current, motion based
- p1994 Pole position identification rise time motion based
- p1995 Pole position identification motion based P gain
- p1996 Pole position identification motion based integral action time
- p1997 Pole position identification motion based smoothing time

Angular commutation offset commissioning support (p1990)

The function for determining the commutation angle offset is activated via $p1990 = 1$.

The commutation angle offset is entered in p0431.

This function can be used in the following cases:

- Single calibration of the pole position for encoders with absolute information (exception: The Hall sensor must always be mechanically adjusted.)
- Calibrating the zero mark position for fine synchronization

Table 3-15 Mode of operation of p0431

	Incremental without zero mark	Incremental with one zero mark	Incremental with distance-coded zero marks	EnDat absolute encoder
C/D track	p0431 shifts the commutation with respect to the C/D track	p0431 shifts the commutation with respect to the C/D track and zero mark	Currently not available	Not permitted
Hall sensor	p0431 does not influence the Hall sensor. The Hall sensor must be mechanically adjusted.	p0431 does not influence the Hall sensor. p0431 shifts the commutation with respect to the zero mark	p0431 does not influence the Hall sensor. p0431 shifts the commutation with respect to the absolute position (after two zero marks have been passed)	Not permitted
Pole position identification	p0431 no effect	p0431 shifts the commutation with respect to the zero mark	p0431 shifts the commutation with respect to the absolute position (after two zero marks have been passed)	p0431 shifts the commutation with respect to the EnDat absolute position

Note

When fault F07414 occurs, p1990 is automatically started; if p1980 is not equal to 99 and p0301 does not refer to a catalog motor with an encoder that is adjusted in the factory.

3.1.14 Vdc control

Description

Vdc control can be activated if overvoltage or undervoltage is present in the DC link line-up. In the line-up, one or more drives can be used to relieve the DC link. This prevents a fault from occurring due to the DC link voltage and ensures that the drives are always ready to use.

This function is activated by means of the configuration parameter (p1240). It can be activated if an overvoltage or undervoltage is present. The torque limits of the motors at which the Vdc controller is active can be affected if discrepancies in the DC link voltage are significant enough. The motors may no longer be able to maintain their setpoint speed or the acceleration/braking phases are prolonged.

The Vdc controller is an automatic P controller that influences the torque limits. It only intervenes when the DC link voltage approaches the "upper threshold" (p1244) or "lower threshold" (p1248) and the corresponding controller is activated via the configuration parameter (p1240).

The recommended setting for the P gain is
 $p1250 = 0.5 \cdot \text{DC link capacitance}[\text{mF}]$.

Once the DC link has been identified (p3410), the DC link capacitance can be read in parameter p3422 in the Infeed Module.

Note

To ensure that the drives remain active if the Line Module has failed, the response to fault F07841 must be changed to "none" or the operation message from the Infeed Module must be permanently set to "1" with p0864.

The Vdc controller can be used, for example, when a Line Module without energy feedback (Vdc_min controller) is used and as a safety measure in the event of a power failure (Vdc_min and Vdc_max controller). To ensure that critical drives can be operated for as long as possible, parameterizable faults exist that switch off individual drives if there is a problem with the DC link.

Description of Vdc_min control (p1240 = 2, 3)

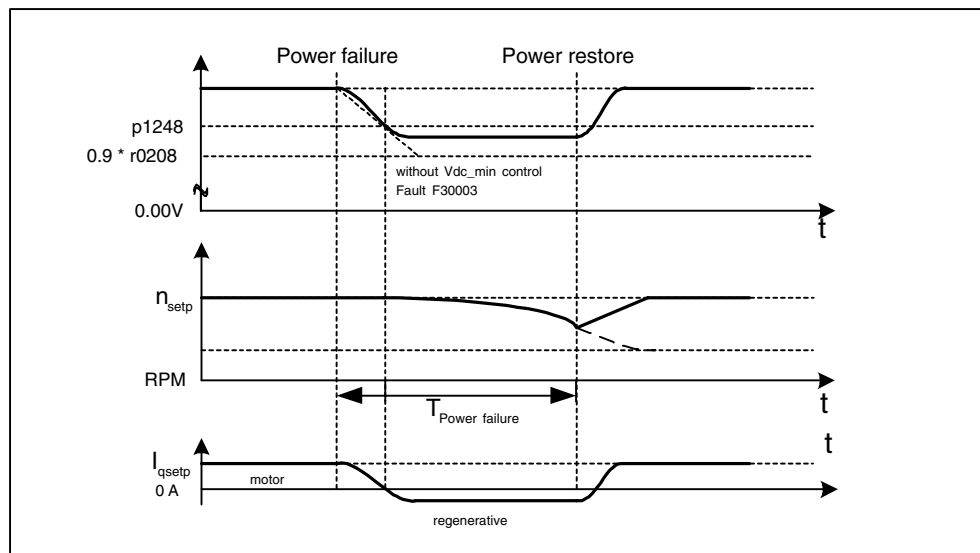


Fig. 3-22 Switching Vdc_min control on/off (kinetic buffering)

In the event of a power failure, the Line Module can no longer supply the DC link voltage, particularly if the Motor Modules in the DC link line-up are drawing active power. To maintain the DC link voltage in the event of a power failure (e.g. for a controlled emergency retraction), the Vdc_min controller can be activated for one or more drives. If the voltage threshold set in p1248 is undershot, these drives are decelerated so that their kinetic energy can be used to maintain the DC link voltage. The threshold should be considerably higher than the shutdown threshold of the Motor Modules (recommendation: 50 V below the DC link voltage). When the power supply is reestablished, the Vdc controller is automatically deactivated and the drives approach the speed setpoint again. If the power supply cannot be reestablished, the DC link voltage collapses if the kinetic energy of the drives is exhausted with an active Vdc_min controller.

Note

You must make sure that the converter is not disconnected from the power supply. It could become disconnected, for example, if the line contactor drops out. The line contactor should have an uninterruptible power supply (UPS), for example.

Description of Vdc_max control (p1240 = 1, 3)

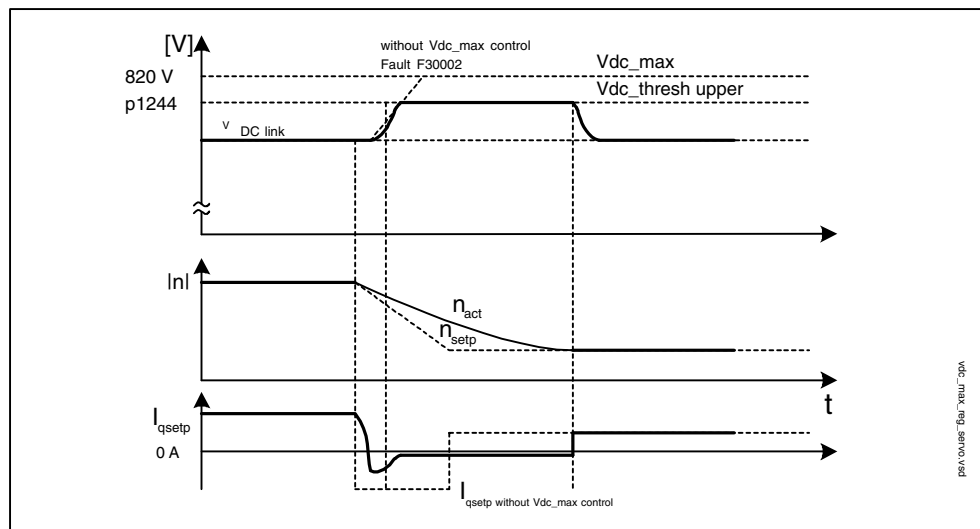


Fig. 3-23 Switching-in/switching-out the Vdc_max control

With Infeed Modules without feedback or in the event of a power failure, the DC link voltage can increase until it reaches the shutdown threshold when drives in the DC link line-up are decelerated. To prevent the system from shutting down due to a DC link overvoltage, the Vdc_max controller can be activated for one or more drives. The Vdc_max controller is normally activated for drives that have to decelerate/accelerate high levels of kinetic energy themselves. When the overvoltage threshold in p1244 is reached (recommended setting: 50 V higher than the DC link voltage), the braking torque of the drives with an active Vdc_max controller is reduced by shifting the torque limit. In this way, the drives feed back the same amount of energy that is used as a result of losses or consumers in the DC link, thereby minimizing the braking time. If other drives for which the Vdc_max controller is not active feed energy back, the drives with an active Vdc_max controller can even be accelerated to absorb the braking energy and, in turn, relieve the DC link.

Vdc controller monitoring functions

In the event of a power failure, the Line Module can no longer supply the DC link voltage, particularly if the Motor Modules in the DC link line-up are drawing active power. To ensure that the DC link voltage is not burdened with uncritical drives in the event of a power failure, these drives can be switched off by a fault with a parameterizable voltage threshold (p1248). This is carried out by activating the Vdc_min monitoring function (p1240 = 5, 6).

In the event of a power failure, the DC link voltage can increase until it reaches the shutdown threshold when drives are decelerated. To ensure that the DC link voltage is not burdened with uncritical drives in the event of a power failure, these drives can be switched off by a fault with a parameterizable voltage threshold (p1244). This is carried out by activating the Vdc_max monitoring function (p1240 = 4, 6).

Function diagram for Vdc controller (see List Manual)

- 5650 Vdc_max controller and Vdc_min controller

Parameters for Vdc controller (see List Manual)

Adjustable parameters

- p1240 Vdc controller or Vdc monitoring configuration
- p1244 DC link voltage threshold, upper
- p1248 DC link voltage threshold, lower
- p1250 Vdc controller proportional gain

Visualization parameters

- r0056.14 Vdc_max controller active
- r0056.15 Vdc_min controller active

3.1.15 Travel to fixed stop

Description

This function can be used to move a motor to a fixed stop at a specified torque without a fault being signaled. When the stop is reached, the specified torque is built up and remains applied.

The desired torque derating is brought about by scaling the upper/motor-mode torque limit and the lower/regenerative-mode torque limit.

Application examples

- Screwing parts together with a defined torque.
- Moving to a mechanical reference point.

Signals

When PROFIBUS telegrams 2 to 6 are used, the following are automatically inter-connected:

- Control word 2, bit 8
- Status word 2, bit 8

Also with PROFIBUS telegrams 102 to 106:

- Process data M_red to the scaling of the torque limit

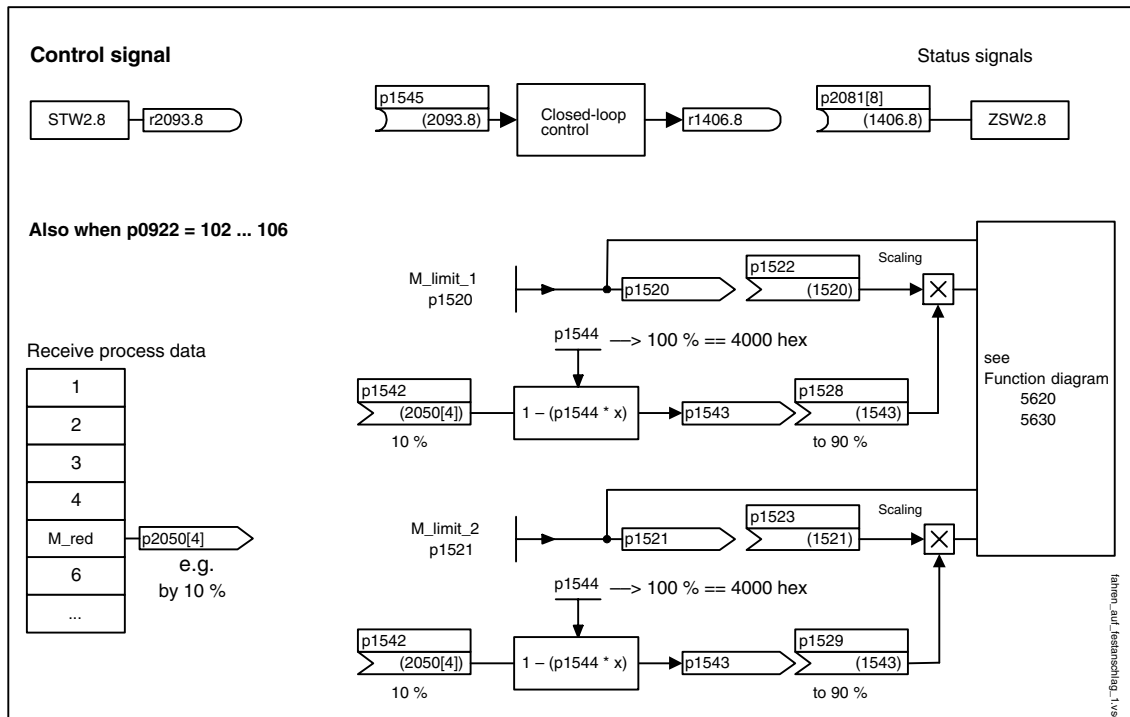


Fig. 3-24 Signals for "Travel to fixed stop"

When PROFIBUS telegrams 2 to 6 are used, no torque reduction is transferred. When the "Travel to fixed stop" function is activated, the motor ramps up to the torque limits specified in p1520 and p1521. If the torque has to be reduced, protocols 102 to 106, for example, can be used to transfer it. Another option would be to enter a fixed value in p2900 and interconnect it to the torque limits p1528 and p1529.

Signal chart

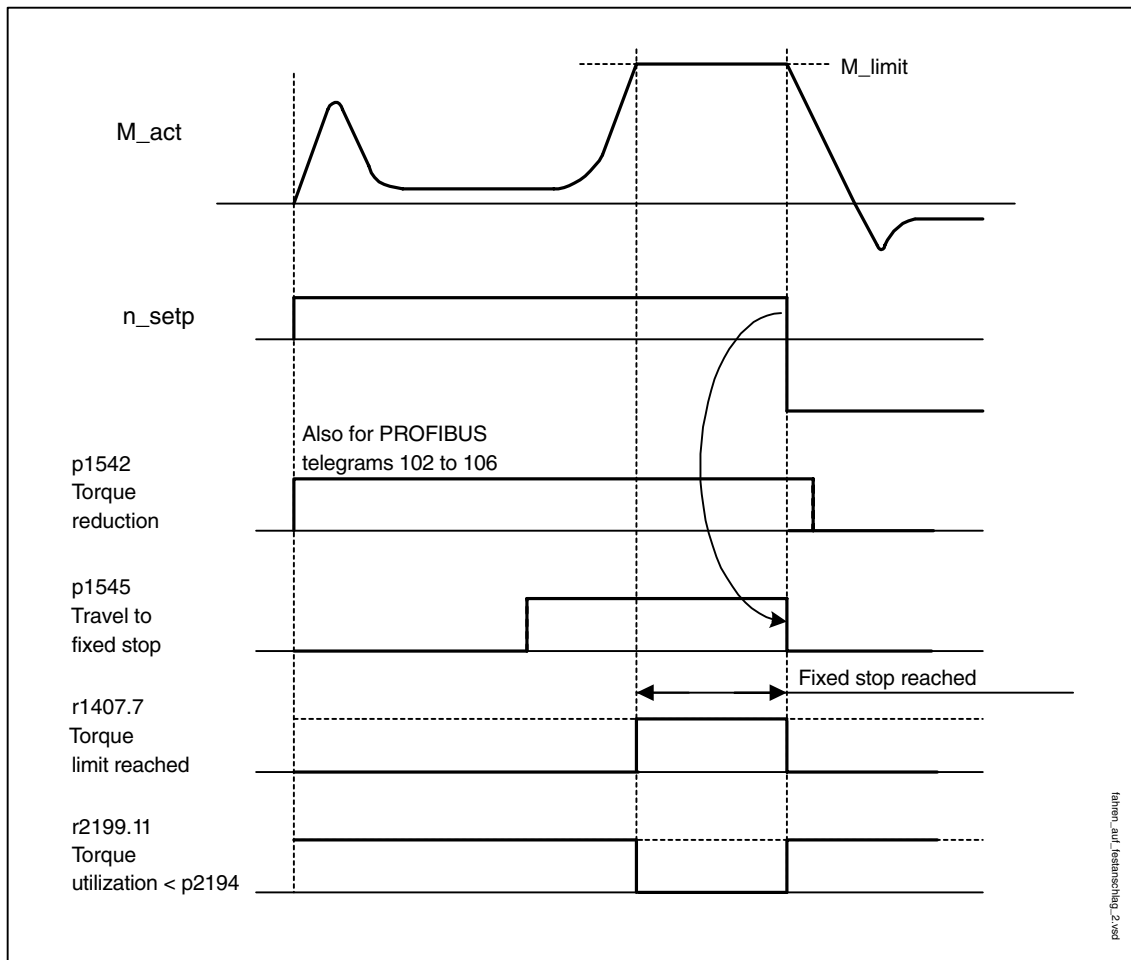


Fig. 3-25 Signal chart for "Travel to fixed stop"

Commissioning

1. Activate travel to fixed end stop

Set p1545 = "1"

2. Set the desired torque limit

Example:

p1400.4 = "0" —> upper or lower torque limit

p1520 = 100 Nm —> effective in upper positive torque direction

p1521 = -1500 Nm —> effective in lower negative torque direction

3. Run motor to fixed stop

The motor runs at the set torque until it reaches the stop and continues to work against the stop until the torque limit has been reached, this status being indicated in status bit r1407.7 "Torque limit reached".

Control and status messages

Table 3-16 Control: Travel to fixed end stop

Signal name	Internal control word STW n-reg	Binector input	PROFIBUS p0922 and/or p2079
Activates travel to a fixed endstop	8	p1545 Activates travel to a fixed endstop	STW2.8

Table 3-17 Status message: Travel to fixed end stop

Signal name	Internal status word ZSW n_ctrl	Parameter	PROFIBUS p0922 and/or p2079
Torque limits reached	ZSW n_ctrl.7	r1407.7	ZSW1.0

Function diagram overview (refer to the List Manual)

- 5610 Torque limitation/reduction/interpolator
- 5620 Motor/generator torque limit
- 5630 Upper/lower torque limit
- 8012 Torque messages, motor blocked/stalled

Parameter overview (see List Manual)

- p1400[0...n] Speed control configuration
- r1407.7 BO: Torque limit reached
- p1520[0...n] CO: Torque limit, upper/motoring
- p1521[0...n] CO: Torque limit, lower/regenerative
- p1522[0...n] CI: Torque limit, upper/motoring
- p1523[0...n] CI: Torque limit, lower/regenerative
- r1526 Upper torque limit of all torque limits without offset
- r1527 Lower torque limit all torque limits without offset
- p1532[0...n] Torque offset torque limit
- p1542[0...n] CI: Travel to a fixed endstop, torque reduction
- r1543 CO: Travel to fixed endstop, torque scaling
- p1544 Travel to a fixed endstop, evaluate torque reduction
- p1545[0...n] BI: Activates travel to a fixed endstop
- p2194[0...n] Torque threshold 2
- p2199.11 BO: Torque utilization < Torque threshold 2

3.1.16 Vertical axes

Description

With a vertical axis without mechanical weight compensation, electronic weight compensation can be set by offsetting the torque limits (p1532). The torque limits specified in p1520 and p1521 are shifted by this offset value.

The offset value can be read in r0031 and transferred in p1532.

To reduce compensation once the brake has been released, the torque offset can be interconnected as a supplementary torque setpoint (p1513).

In this way, the holding torque is set as soon as the brake has been released.

Overview of important parameters (refer to the List Manual)

- r0031 Actual torque smoothed
- p1513 CI: Supplementary torque 2
- p1520 CO: Torque limit, upper/motoring
- p1521 CO: Torque limit, lower/regenerative
- p1532 CO: Torque limit, offset

Function diagram overview (refer to the List Manual)

- 5060 Torque setpoint, control mode switchover
- 5620 Motor/generator torque limit
- 5630 Upper/lower torque limit

3.2 Vector control

Compared with vector V/f control, vector control offers the following benefits:

- Stability vis-à-vis load and setpoint changes
- Short rise times with setpoint changes (→ better command behavior)
- Short settling times with load changes (→ better disturbance characteristic)
- Acceleration and braking are possible with maximum available torque
- Motor protection due to variable torque limitation in motor and regenerative mode
- Drive and braking torque controlled independently of the speed
- Maximum breakaway torque possible at speed 0

Vector control can be used with or without an encoder.

The following criteria indicate when an encoder is required:

- High speed accuracy is required
- High dynamic response requirements
 - Better command behavior
 - Better disturbance characteristic
- Torque control is required in a control range greater than 1:10
- Allows a defined and/or variable torque for speeds below approx. 10 % of the rated motor frequency (p0310) to be maintained.

With regard to setpoint input, vector control is divided into:

- Speed control
- Torque/current control (in short: torque control)

3.2.1 Vector control without encoder (SLVC)

In vector control without an encoder (SLVC), the position of the flux and actual speed must be determined via the electric motor model. The model is buffered by the incoming currents and voltages. At low frequencies (approx. 0 Hz), the model cannot determine the speed. For this reason and due to uncertainties in the model parameters or inaccurate measurements, the system is switched from closed-loop to open-loop operation in this range.

The changeover between closed-loop/open-loop controlled operation is controlled using time and frequency conditions (p1755, p1756, p1758 – only for induction motors). The system does not wait for the time condition to elapse when the setpoint frequency at the ramp-function generator input and the actual frequency are below $p1755 * (1 - p1756)$ simultaneously.

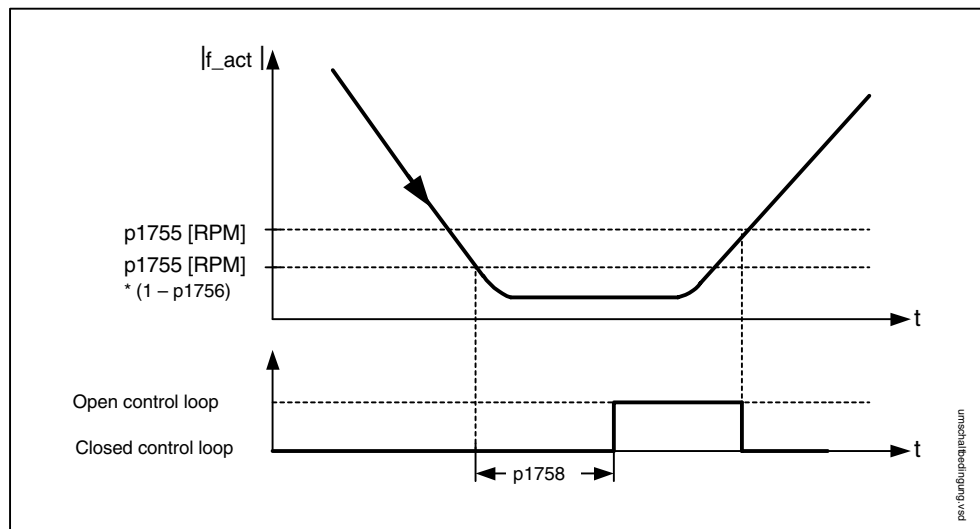


Fig. 3-26 Switchover conditions for SLVC

In open-loop operation, the calculated actual speed value is the same as the setpoint value. For vertical loads and acceleration, parameters p1610 (constant torque boost) and p1611 (acceleration torque boost) must be modified in order to generate the static or dynamic load torque of the drive. If, for induction motors (ASM), p1610 is set to 0 %, only the magnetizing current r0331 is injected; when the value is 100 %, the rated motor current p0305 is injected. For permanent-magnet synchronous motors (PEM), for p1610 = 0 %, a pre-control absolute value, derived from the supplementary torque r1515, remains instead of the magnetizing current for ASM. To ensure that the drive does not stall during acceleration, p1611 can be increased or acceleration pre-control for the speed controller can be used. This is also advisable to ensure that the motor is not subject to thermal overload at low speeds.

Vector control without a speed sensor has the following characteristics at low frequencies:

- Closed-loop operation up to approx. 1 Hz output frequency
- Starting in closed-loop controlled operation (directly after the drive has been energized) (only ASM)

Note

In this case, the speed setpoint upstream of the ramp-function generator must be greater than (p1755).

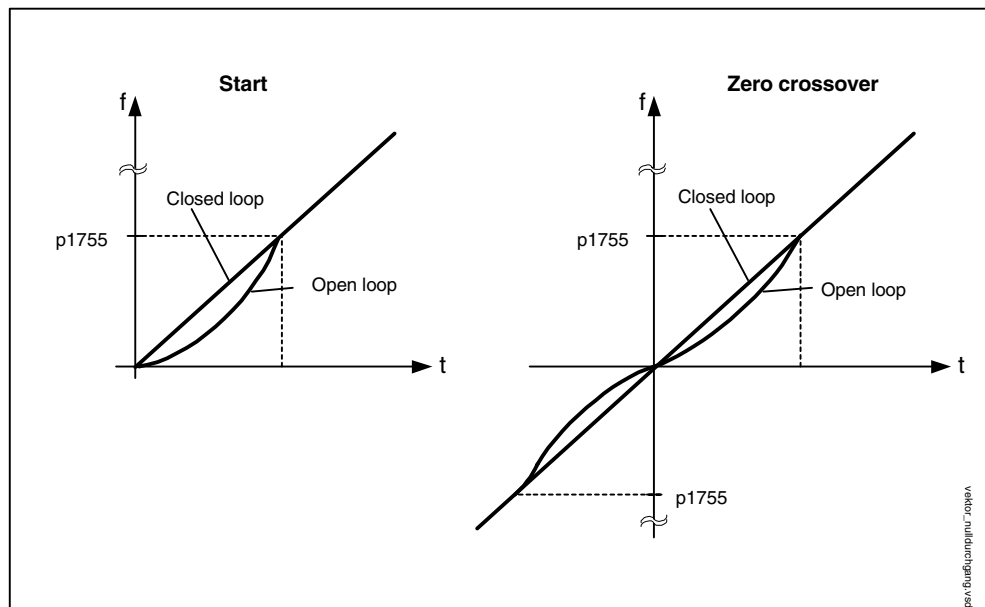


Fig. 3-27 Start-up and passing through 0 Hz in closed-loop operation

Closed-loop operation up to approx. 1 Hz (settable via parameter p1755) and the ability to start or reverse at 0 Hz directly in closed-loop operation (settable via parameter p1750) result in the following benefits:

- No switchover required within closed-loop control (smooth operation, no dips in frequency).
- Steady-state speed-torque control up to approx. 1 Hz.

Note

When the motor is started or reversed in closed-loop operation at 0 Hz, it is important to take into account that the system switches from closed-loop to open-loop control automatically if the system remains in the 0 Hz range for too long (> 2 s or > p1758).

Function diagram overview (refer to the List Manual)

- 6730 Interface with Motor Module for induction motor (p0300 = 1)
- 6731 Interface to the Motor Module (PEM, p0300 = 2)

Parameter overview (see List Manual)

- p0305[0...n] Rated motor current
- r0331[0...n] Motor magnetizing current/short-circuit current (actual)
- p1610[0...n] Torque setpoint static (SLVC)
- p1611[0...n] Supplementary accelerating torque (SLVC)
- p1750[0...n] Motor model configuration
- p1755[0...n] Motor model without encoder, changeover speed
- p1756 Motor model changeover speed hysteresis
- p1758[0...n] Motor model changeover delay time, open/closed-loop control

3.2.2 Vector control with encoder (VC)**Benefits of vector control with an encoder:**

- The speed can be controlled right down to 0 Hz (standstill)
- Constant torque in the rated speed range
- Compared with speed control without an encoder, the dynamic response of drives with an encoder is significantly better because the speed is measured directly and integrated in the model created for the current components.
- Higher speed accuracy

3.2.3 Speed controller

Both closed-loop control procedures with and without an encoder (VC, SLVC) have the same speed controller structure, which contains the following components:

- PI controller
- Speed controller pre-control
- Droop function

The total of the output variables result in the torque setpoint, which is reduced to the permissible magnitude by means of the torque setpoint limitation.

Speed controller

The speed controller receives its setpoint (r0062) from the setpoint channel and its actual value (r0063) either directly from the speed sensor (control with sensor (VC)) or indirectly via the motor model (control without sensor (SLVC)). The system deviation is increased by the PI controller and, in conjunction with the pre-control, results in the torque setpoint.

When the load torque increases, the speed setpoint is reduced proportionately when the droop function is active, which means that the single drive within a group (two or more mechanically connected motors) is relieved when the torque becomes too great.

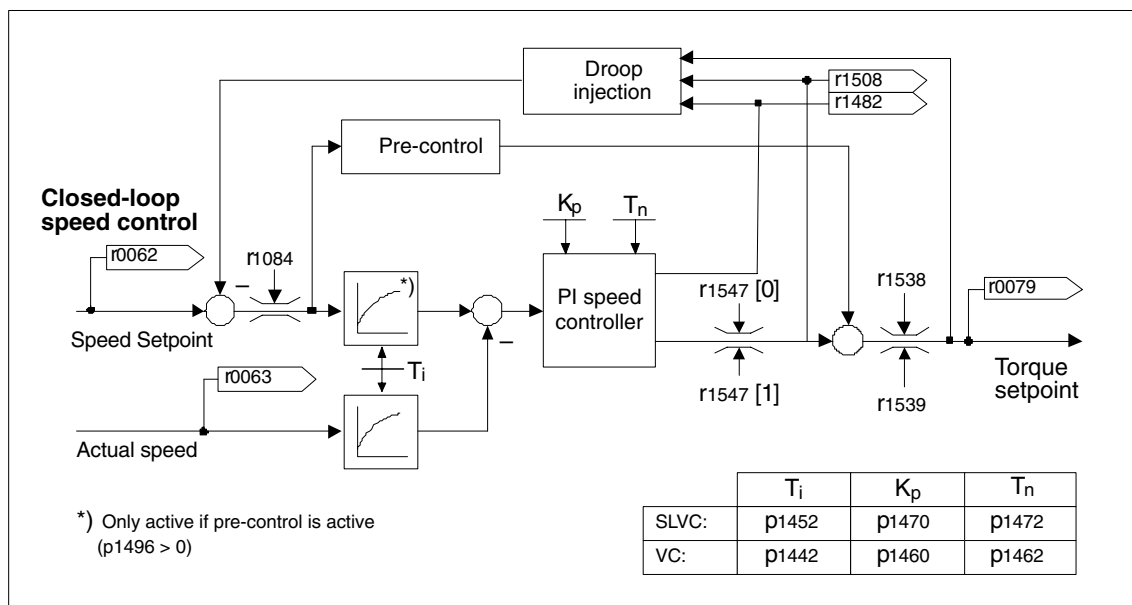


Fig. 3-28 Speed controller

The optimum speed controller setting can be determined via the automatic speed controller optimization function (p1900 = 1, rotating measurement) (see also: Subsection 3.2.11).

If the inertia load has been specified, the speed controller (K_p , T_n) can be calculated by means of automatic parameterization ($p0340 = 4$). The controller parameters are defined in accordance with the symmetrical optimum as follows:

$$T_n = 4 * T_s$$

$$K_p = 0.5 * r0345 / T_s = 2 * r0345 / T_n$$

T_s = total of the short delay times (contains $p1442$ and $p1452$)

If vibrations occur with these settings, the speed controller gain K_p must be reduced manually. Actual speed value smoothing can also be increased (standard procedure for gearless or high-frequency torsion vibrations) and the controller calculation performed again because this value is also used to calculate K_p and T_n .

The following relationships apply for optimization:

- If K_p is increased, the controller becomes faster, although overshoot is reduced. Signal ripples and vibrations in the speed control loop, however, increase.
- If T_n is decreased, the controller still becomes faster, although overshoot is increased.

When speed control is set manually, it is easiest to define the possible dynamic response via K_p (and actual speed value smoothing) first before reducing the integral time as much as possible. When doing so, closed-loop control must also remain stable in the field-weakening range.

To suppress any vibrations that occur in the speed controller, it is usually only necessary to increase the smoothing time in $p1452$ for operation with an encoder or $p1442$ for operation without an encoder or reduce the controller gain.

The integral output of the speed controller can be monitored via $r1482$ and the limited controller output via $r1508$ (torque setpoint).

Note

In comparison with speed control with an encoder, the dynamic response of drives without an encoder is significantly reduced. The actual speed is derived by means of a model calculation from the converter output variables for current and voltage that have a corresponding interference level. To this end, the actual speed must be adjusted by means of filter algorithms in the software.

Parameter overview (see List Manual)

- p0340[0...n] Automatic calculation of control parameters
- p1442[0...n] Actual speed smoothing time
- p1452[0...n] Speed actual value smoothing time (SLVC)
- p1460[0...n] Lower adaptation speed P gain speed controller
- p1462[0...n] Speed controller integral action time adaptation speed, lower
- p1470[0...n] Speed controller sensorless operation P-gain
- p1472[0...n] Speed controller sensorless operation integral-action time
- p1960 Speed controller optimization selection
- r0062 CO: Speed setpoint after the filter
- r0063[0...1] CO: Actual speed
- r0345[0...n] Nominal motor starting time
- r1482 CO: Speed controller I torque output
- r1508 CO: Torque setpoint before supplementary torque

Function diagram overview

- 6040 Speed controller with/without encoder

3.2.4 Speed controller adaptation

Description

Two adaptation methods are available, namely free K_p _n adaptation and speed-dependent K_p _n/ T_n _n adaptation.

Free K_p _n adaptation is also active in “operation without encoder” mode and is used in “operation with encoder” mode as an additional factor for speed-dependent K_p _n adaptation.

Speed-dependent K_p _n/ T_n _n adaptation is only active in “operation with encoder” mode and also affects the T_n _n value.

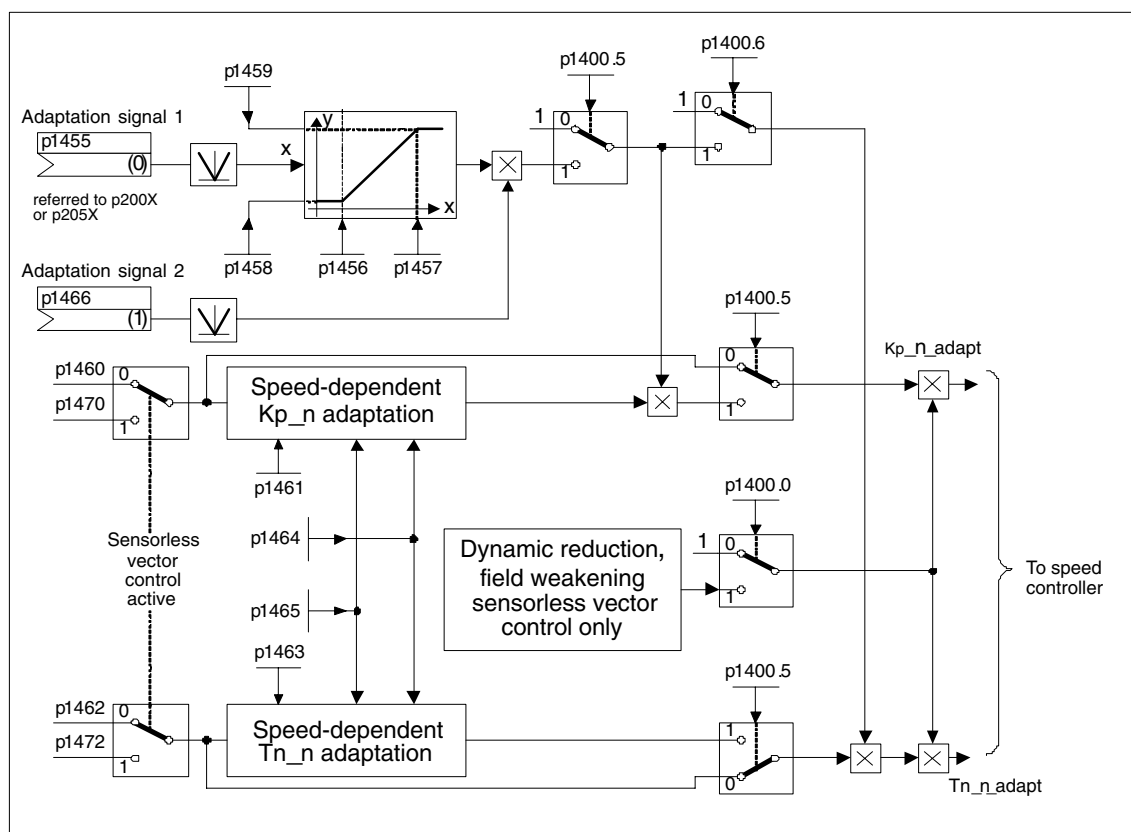


Fig. 3-29 Free KP adaptation

Dynamic response reduction in the field-weakening range can be activated (p1400.0) with sensorless operation. This is activated when the speed controller is optimized in order to achieve a greater dynamic response in the basic speed range.

Example of speed-dependent adaptation

Note

This type of adaptation is only active in “operation with encoder” mode.

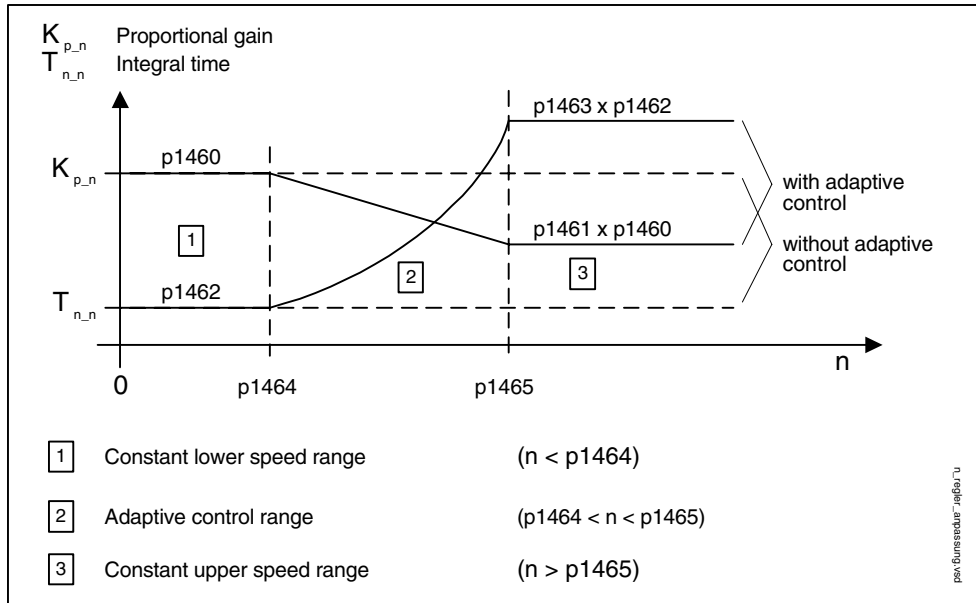


Fig. 3-30 Speed controller $K_{p,n}/T_{n,n}$ adaptation

Parameterization

The “speed controller” parameter screen is selected via the following icon in the toolbar of the STARTER commissioning tool:



Fig. 3-31 STARTER icon for “speed controller”

Parameter overview for speed controller adaptation (refer to the List Manual)

- p1400.5[0...n] Speed control configuration: Kp/Tn adaptation active

Free Kp_n adaptation

- p1455[0...n] CI: Speed controller P gain adaptation signal
- p1456[0...n] Lower starting point adaptation P gain
- p1457[0...n] Speed controller P gain adaptation application point upper
- p1458[0...n] Lower adaptation factor
- p1459[0...n] Adaptation factor, upper
- p1470[0...n] Speed controller sensorless operation P-gain

Speed-dependent Kp_n/Tn_n adaptation (VC only)

- p1460[0...n] Lower adaptation speed P gain speed controller
- p1461[0...n] Upper adaptation speed P gain speed controller
- p1462[0...n] Speed controller integral action time adaptation speed, lower
- p1463[0...n] Integral time upper adaptation speed speed controller
- p1464[0...n] Lower adaptation speed speed controller
- p1465[0...n] Upper adaptation speed speed controller
- p1466[0...n] CI: Speed controller P-gain scaling

Dynamic response reduction field weakening (SLVC only)

- p1400.0[0...n] Speed control configuration: Automatic Kp/Tn adaptation active

Function diagram for speed controller adaptation (see List Manual)

- 6050 Kp_n and Tn_n adaptation

3.2.5 Speed controller pre-control and reference model

The command behavior of the speed control loop can be improved by calculating the accelerating torque from the speed setpoint and connecting it on the line side of the speed controller. This torque setpoint (mv) is calculated as follows:

$$mv = p1496 \times J \times \frac{dn}{dt} = p1496 \times p0341 \times p0342 \times \frac{dn}{dt}$$

The torque setpoint is switched/pre-controlled directly to the current controller via adaptors as supplementary command variables (enabled via p1496).

The motor moment of inertia p0341 is calculated directly during commissioning or when the entire set of parameters is calculated (p0340 = 1). The factor p0342 between the total moment of inertia J and the motor moment of inertia must be determined manually or by means of speed controller optimization. The acceleration is calculated from the speed difference over the time dn/dt.

Note

When speed controller optimization is carried out, the ratio between the total moment of inertia and that of the motor (p0342) is determined and acceleration pre-control scaling (p1496) is set to 100 %.

When p1400.2 = p1400.3 = 0, pre-control balancing is set automatically.

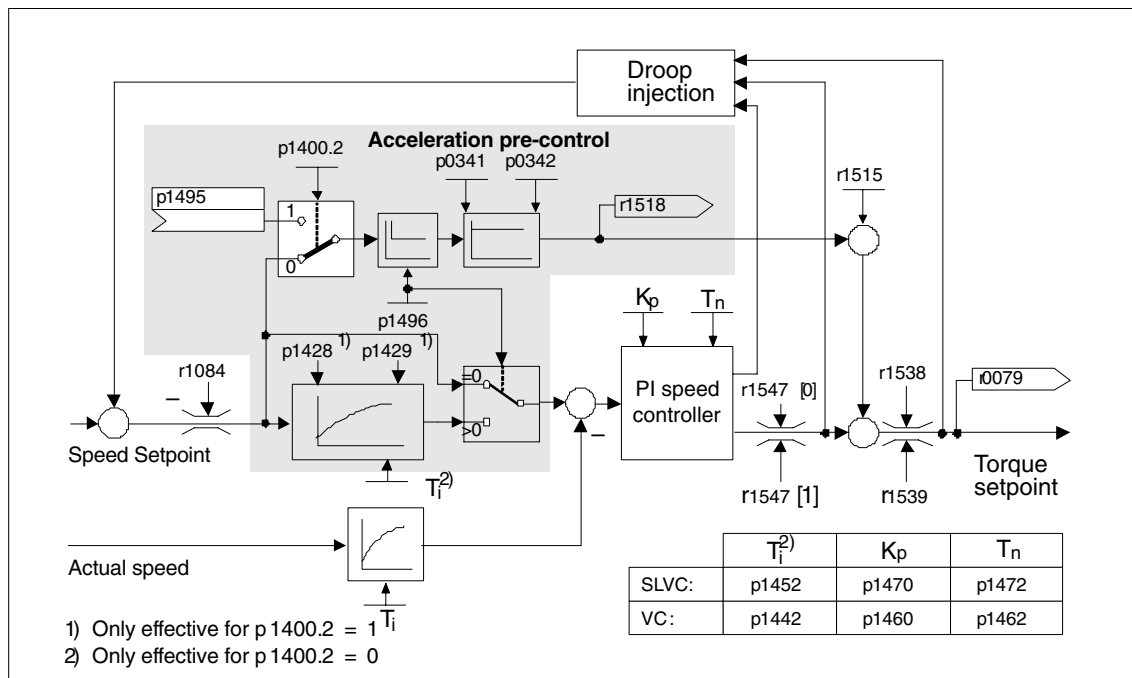


Fig. 3-32 Speed controller with pre-control

If the speed controller has been correctly adjusted, it only has to compensate for disturbance variables in its own control loop, which can be achieved by means of a relatively small change to the correcting variables. Speed setpoint changes, on the other hand, are carried out without involving the speed controller and are, therefore, performed more quickly.

The effect of the pre-control variable can be adapted according to the application via the evaluation factor p1496. If p1496 = 100 %, pre-control is calculated in accordance with the motor and load moment of inertia (p0341, p0342). A balancing filter is used automatically to prevent the speed controller from acting against the injected torque setpoint. The time constant of the balancing filter corresponds to the equivalent delay time of the speed control loop. Speed controller pre-control is correctly set (p1496 = 100 %, calibration via p0342) when the I component of the speed controller (r1482) does not change during a ramp-up or ramp-down in the range $n > 20 \% \cdot p0310$. Thus, the pre-control allows a new speed setpoint to be approached without overshoot (prerequisite: the torque limiting does not act and the moment of inertia remains constant).

If the speed controller is pre-controlled through injection, the speed setpoint (r0062) is delayed with the same smoothing time (p1442 or p1452) as the actual value (r1445). This ensures that no target/actual difference (r0064) occurs at the controller input during acceleration, which would be attributable solely to the signal propagation time.

When speed pre-control is activated, the speed setpoint must be specified continuously or without a higher interference level (avoids sudden torque changes). An appropriate signal can be generated by smoothing the speed setpoint or activating the ramp-function generator rounding-off p1130 – p1131.

The starting time r0345 (T_{start}) is a measure for the total moment of inertia J of the machine and describes the time during which the unloaded drive can be accelerated with the rated motor torque r0333 ($M_{\text{mot, rated}}$) from standstill to the rated motor speed p0311 ($n_{\text{mot, rated}}$).

$$r0345 = T_{\text{start}} = J \times \frac{(2\pi \times n_{\text{mot, rated}})}{(60 \times M_{\text{mot, rated}})} = p0341 \times p0342 \times \frac{(2\pi \times p0311)}{(60 \times r0333)}$$

If these basic conditions are in line with the application, the starting time can be used as the lowest value for the ramp-up or ramp-down time.

Note

The ramp-up and ramp-down times (p1120; p1121) of the ramp-function generator in the setpoint channel should be set accordingly so that the motor speed can track the setpoint during acceleration and braking. This ensures that speed controller pre-control is functioning optimally.

Acceleration pre-control via the connector input (p1495) is activated via parameter settings p1400.2 = 1 and p1400.3 = 0. p1428 (dead time) and p1429 (time constant) can be set for balancing purposes.

Reference model

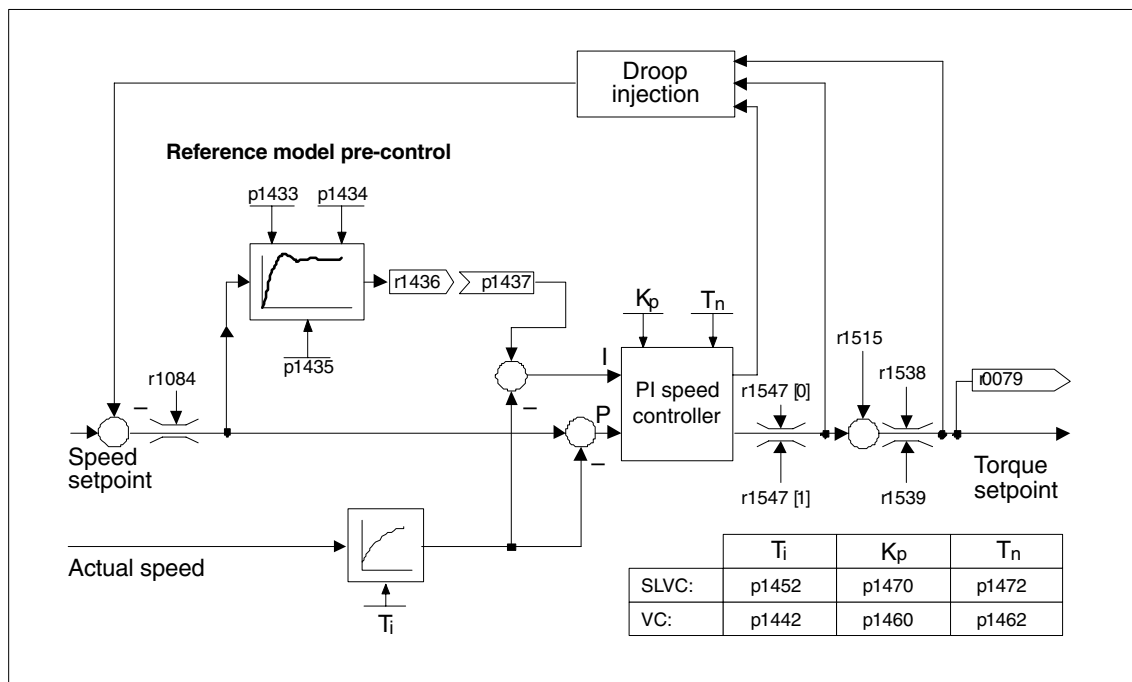


Fig. 3-33 Reference model

The reference model is activated when p1400.3 = 1 and p1400.2 = 0.

The reference model is used to emulate the path of the speed control loop with a P speed controller.

The path emulation can be set in p1433 to p1435. It is activated when p1437 is connected to the output of model r1436.

The reference model delays the setpoint-actual deviation for the integral component of the speed controller so that transient conditions can be suppressed.

The reference model can also be emulated externally and its output signal injected via p1437.

Function diagram overview for speed controller pre-control

- 6031 Pre-control balancing for reference/acceleration model
- 6040 Speed controller

Parameter overview for speed controller pre-control

- p0311[0...n] Rated motor speed
- r0333[0...n] Rated motor torque
- p0341[0...n] Motor moment of inertia
- p0342[0...n] Ratio between the total moment of inertia and that of the motor
- r0345[0...n] Nominal motor starting time
- p1400.2[0...n] Acceleration pre-control source
- p1428[0...n] Speed precontrol deadtime for balancing pre-control speed
- p1429[0...n] Speed pre-control time constant for balancing
- p1496[0...n] Acceleration precontrol scaling
- r1518 CO: Accelerating torque

For reference model

- p1400.3[0...n] Reference model speed setpoint I component
- p1433[0...n] Speed controller reference model natural frequency
- p1434[0...n] Speed controller reference model damping
- p1435[0...n] Speed controller reference model deadtime
- p1436 CO: Speed controller reference model speed setpoint output
- p1437[0...n] CI: Speed controller, reference model I component input

3.2.6 Droop function

The droop function (enabled via p1492) ensures that the speed setpoint is reduced proportionally as the load torque increases.

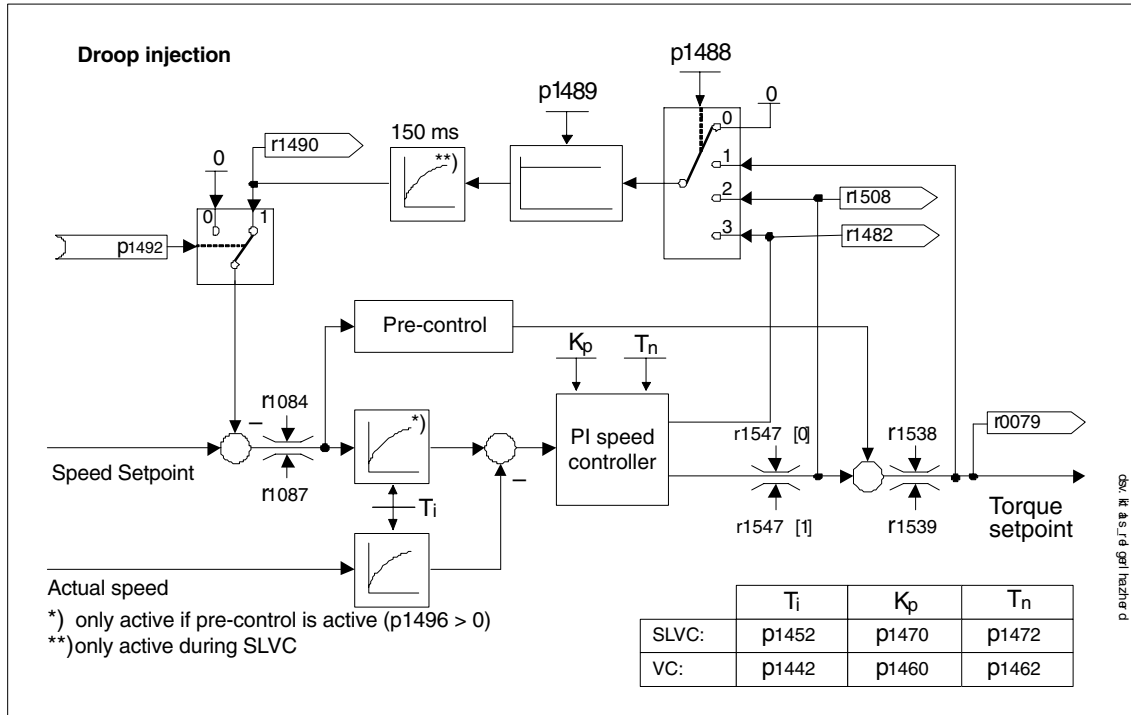


Fig. 3-34 Speed controller with droop function

Drooping is the most straightforward way of controlling load balancing. This type of control can only be applied, however, if the drives are operated in motor mode and the speed is steady state. This method is only suitable to a limited extent for drives that are accelerated and braked with significant changes in speed.

This simple type of load balancing control is used, for example, in applications in which two or more motors are connected mechanically or operate with a common shaft and fulfill the above requirements. The droop function compensates for torque differences that can occur as a result of the mechanical connection between the motors by modifying the speeds of the individual motors (drive is relieved when the torque becomes too great).

Preconditions

- All connected drives must be operated with vector control and speed control (with or without an encoder).
- The ramp-function generator ramp-up and ramp-down times must be the same for all drives.

Function diagram overview for droop function (see List Manual)

- 6030 Speed setpoint, droop, acceleration model

Parameter overview for droop function (see List Manual)

- p1488[0...n] Droop input source
- p1489[0...n] Droop feedback scaling
- p1492[0...n] BI: Droop feedback enable
- r1482 CO: Speed controller I torque output
- r1490 CO: Droop feedback speed reduction
- p1512 CI: Supplementary torque 1 scaling
- p1513 CI: Supplementary torque 2

3.2.7 Torque control

With sensorless speed control SLVC (p1300 = 20) or speed control with sensor VC (p1300 = 21), a switchover can be made to torque control (slave drive) via BICO parameter p1501. A switchover cannot be made between speed and torque control if torque control is selected directly with p1300 = 22 or 23. The torque setpoint and/or supplementary setpoint can be entered using BICO parameter p1503 (CI: torque setpoint) or p1511 (CI: supplementary torque setpoint). The supplementary torque is active both with torque and speed control. This particular feature with the supplementary torque setpoint allows a pre-control torque to be applied for speed control.

Note

For safety reasons, assignments to fixed torque setpoints are currently not possible.

When regenerative energy occurs that cannot be fed back into the supply, a Braking Module with a connected braking resistor must be used.

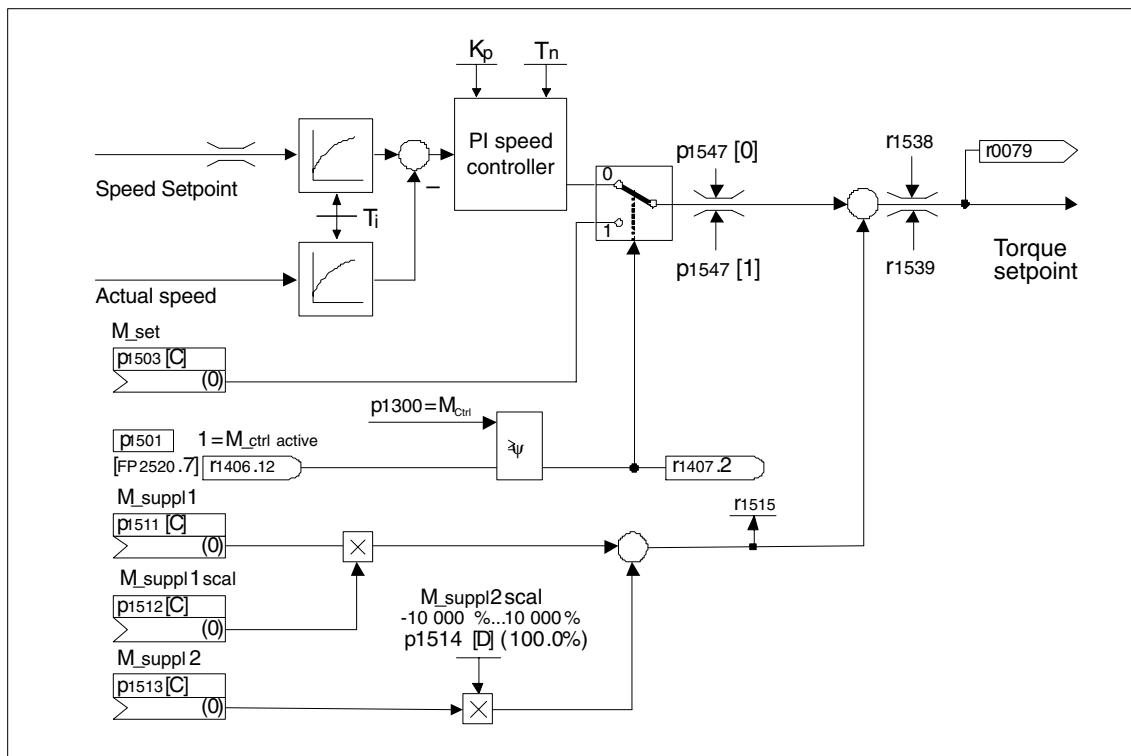


Fig. 3-35 Closed-loop speed/torque control

The total of the two torque setpoints is limited in the same way as the speed control torque setpoint. At speeds in excess of the maximum speed (p1182), a speed limiter reduces the torque limits to prevent the drive from being accelerated further.

True torque control (with self-adjusting speed) is only possible in closed-loop but not open-loop control for sensorless vector control (SLVC). In open-loop control, the torque setpoint adjusts the setpoint speed via a ramp-function generator (integration time ~ p1499 x p0341 x p0342). For this reason, sensorless torque control at standstill is only suitable for applications that require an accelerating torque but no load torque (e.g. traction drives). This restriction does not apply to torque control with sensor.

OFF responses

- OFF1 and p1300 = 22, 23
 - Reaction as for OFF2
- OFF1, p1501 = "1" signal and p1300 ≠ 22, 23
 - No separate braking response; the braking response takes place by a drive that specifies the torque.
 - The pulses are suppressed when the brake application time (p1217) expires. Zero speed is detected if the actual speed drops below the threshold in p1226 or if the monitoring time (p1227) started when speed setpoint ≤ speed threshold (p1226) has expired.
 - Power-on disable is activated.
- OFF2
 - Instantaneous pulse suppression, the drive "coasts" to a standstill.
 - The motor brake (if parameterized) is closed immediately.
 - Power-on disable is activated.
- OFF3
 - Switch to speed-controlled operation
 - n_set=0 is input immediately to brake the drive along the OFF3 deceleration ramp (p1135).
 - When zero speed is detected, the motor brake (if parameterized) is closed.
 - The pulses are suppressed when the motor brake application time (p1217) has elapsed. Zero speed is detected if the actual speed drops below the threshold in p1226 or if the monitoring time (p1227) started when speed setpoint ≤ speed threshold (p1226) has expired.
 - Power-on disable is activated.

Function diagrams for torque setpoint limitation (see List Manual)

- 6060 Torque setpoint

Parameters for torque control (see List Manual)

- p0341[0...n] Motor moment of inertia
- p0342[0...n] Ratio between the total moment of inertia and that of the motor
- p1300[0...n] Open-loop/closed-loop control operating mode
- p1499[0...n] Acceleration for torque control (SLVC) scaling
- p1501[0...n] BI: Change over between closed-loop speed/torque control
- p1503[0...n] CI: Torque setpoint
- p1511[0...n] CI: Supplementary torque 1
- r1512 CI: Supplementary torque 1 scaling
- r1513 CI: Supplementary torque 2
- r1514 Supplementary torque 2 scaling
- r1515 Supplementary torque total

3.2.8 Torque limiting

Description

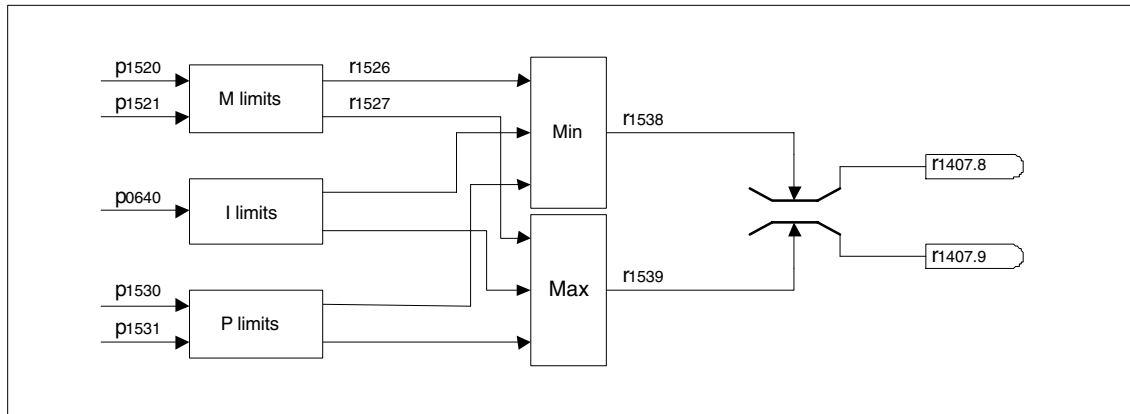


Fig. 3-36 Torque limiting

The value specifies the maximum permissible torque whereby different limits can be parameterized for motor and regenerative mode.

- p0640[0...n] Current limit
- p1520[0...n] CO: Torque limit, upper/motoring
- p1521[0...n] CO: Torque limit, lower/regenerative
- p1522[0...n] CI: Torque limit, upper/motoring
- p1523[0...n] CI: Torque limit, lower/regenerative
- p1524[0...n] CO: Torque limit, upper/motoring, scaling
- p1525[0...n] CO: Torque limit, lower/regenerating scaling
- p1530[0...n] Power limit, motor mode
- p1531[0...n] Power limit, regenerative mode

The current active torque limit values are displayed in the following parameters:

- r0067 Maximum drive output current
- r1526 Upper torque limit of all torque limits without offset
- r1527 Lower torque limit all torque limits without offset

The following limits all apply to the torque setpoint, which is present either at the speed controller output in the case of speed control, or at the torque input in the case of torque control. The minimum/maximum value of the different limits is used in each case. The minimum value is calculated cyclically and displayed in parameters r1538 and r1539.

- r1538 CO: Upper effective torque limit
- r1539 CO: Lower effective torque limit

These cyclical values, therefore, limit the torque setpoint at the speed controller output/torque input and indicate the maximum torque currently possible. If the torque setpoint is limited in the Motor Module, this is indicated via the following diagnostic parameters:

- r1407.8 Upper torque limit active
- r1407.9 Lower torque limit active

Function diagrams for torque setpoint limitation (see List Manual)

- 6060 Torque setpoint
- 6630 Upper/lower torque limit
- 6640 Current/power/torque limits

3.2.9 Vdc control

Description

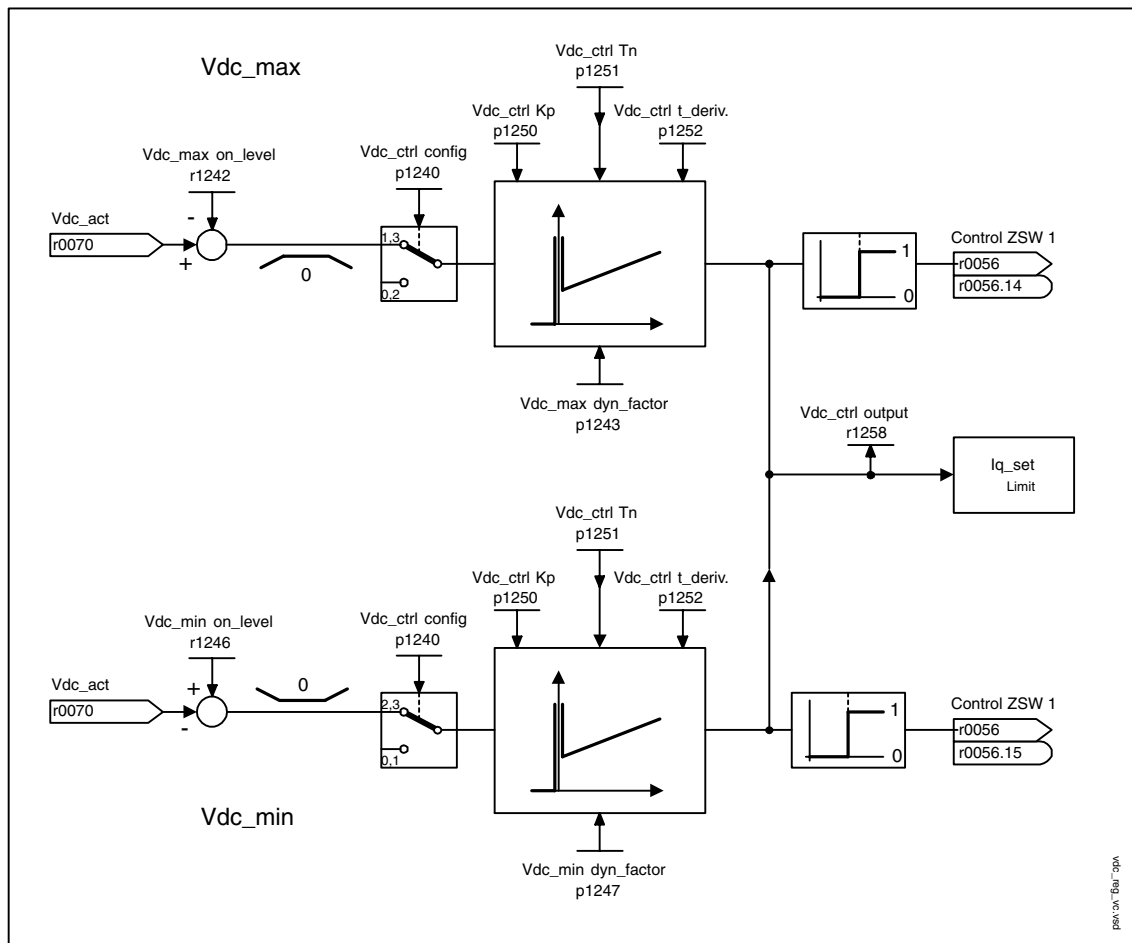


Fig. 3-37 Vdc control vector

The “Vdc control” function can be activated using the appropriate measures if an overvoltage or undervoltage is present in the DC link.

- Overvoltage in the DC link
 - Typical cause
The drive is operating in regenerative mode and is supplying too much energy to the DC link.
 - Remedy
Reduce the regenerative torque to maintain the DC link voltage within permissible limits.
- Undervoltage in the DC link
 - Typical cause
Failure of the supply voltage or supply for the DC link.
 - Remedy
Specify a regenerative torque for the rotating drive to compensate the existing losses, thereby stabilizing the voltage in the DC link (kinetic buffering).

Properties

- Vdc control
 - This comprises Vdc_max control and Vdc_min control (kinetic buffering), which are independent of each other.
 - Joint PI controller. The dynamic factor is used to set Vdc_min and Vdc_max control independently of each other.
- Vdc_max control
 - This function can be used to control momentary regenerative load without shutdown with “overvoltage in the DC link”.
 - Vdc_max control is only recommended with a supply without active closed-loop control for the DC link and without feedback.
- Vdc_min control (kinetic buffering)
 - With this function, the kinetic energy of the motor is used for buffering the DC link voltage in the event of a momentary power failure, thereby delaying the drive.

Description of Vdc_min control

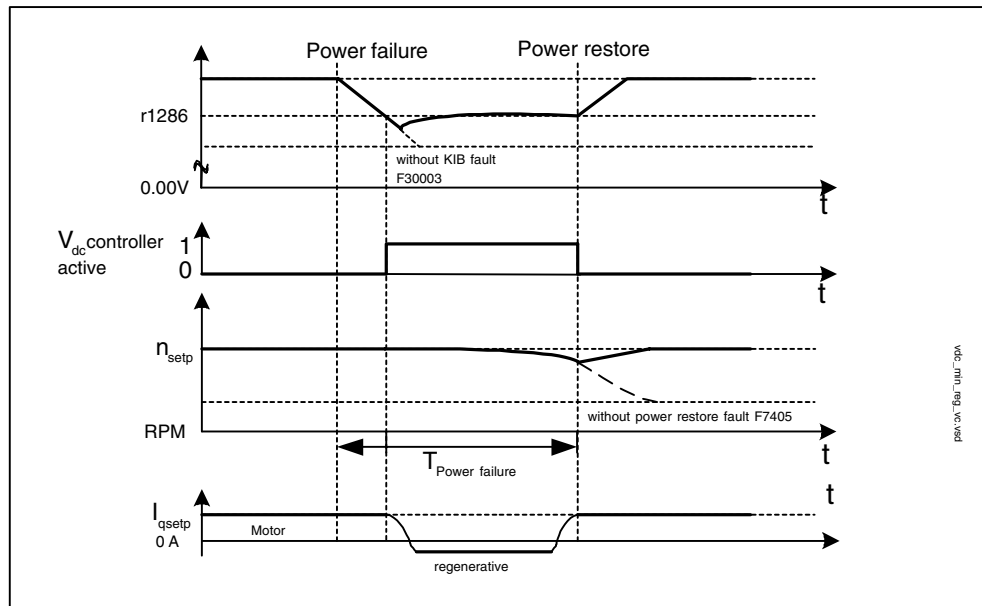


Fig. 3-38 Switching Vdc_min control on/off (kinetic buffering)

In the event of a power failure, Vdc_min control is activated when the Vdc_min switch-in level is undershot. This controls the DC link voltage and maintains it at a constant level. The motor speed is reduced.

When the power supply is restored, the DC link voltage increases again and Vdc_min control is deactivated at 5 % above the Vdc_min switch-on level. The motor continues operating normally.

If the power supply is not reestablished, the motor speed continues to drop. When the threshold in p1257 is reached, this results in a response in accordance with p1256.

Once the time threshold (p1255) has elapsed without the line voltage being reestablished, a fault is triggered (F07406), which can be parameterized as required (factory setting: OFF3).

Note

You must make sure that the converter is not disconnected from the power supply. It could become disconnected, for example, if the line contactor drops out. The line contactor should have an uninterruptible power supply (UPS), for example.

Description of Vdc_max control

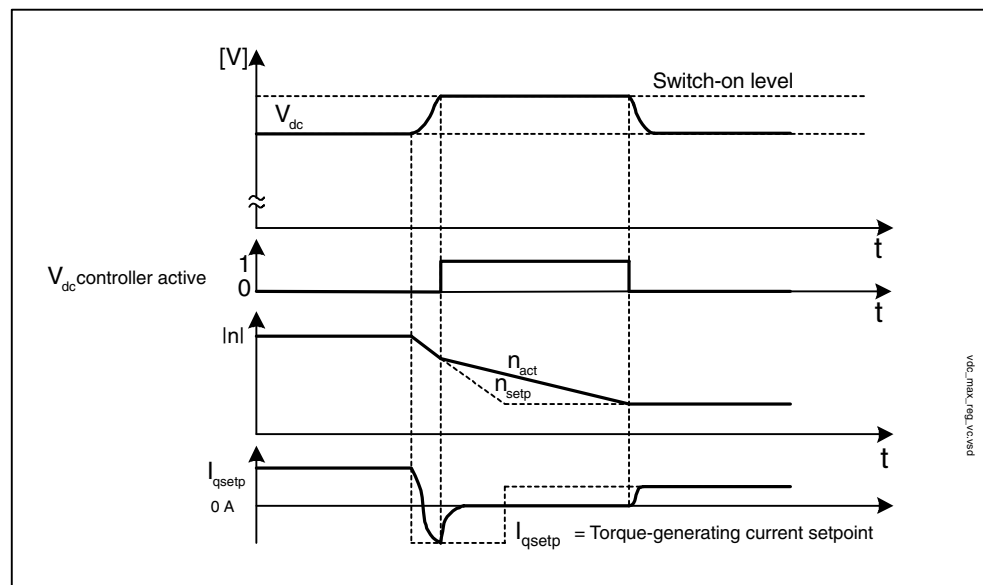


Fig. 3-39 Switching Vdc_max control on/off

The switch-in level for Vdc_max control (r1242) is calculated as follows:

- Automatic detection of ON level deactivated (p1254 = 0)
 $r1242 = 1.15 * p0210$ (device supply voltage, DC link)
- Automatic detection of ON level activated (p1254 = 1)
 $r1242 = V_{dc_max} - 50 \text{ V}$ (V_{dc_max} : overvoltage threshold of the Motor Module)

Function diagrams (refer to the List Manual)

- 6220 Vdc_max controller and Vdc_min controller

Parameters for Vdc controller (see List Manual)

- p1240[0...n] Vdc controller or Vdc monitoring configuration
- r1242 Vdc_max controller switch-in level
- p1243[0...n] Vdc_max controller dynamic factor (control)
- p1245[0...n] Vdc_min controller switch-in level (kinetic buffering) (control)
- r1246 Vdc_min controller switch-in level (kinetic buffering) (control)
- p1247[0...n] Vdc_min controller dynamic factor (kinetic buffering) (control)
- p1250[0...n] Vdc controller proportional gain (control)
- p1251[0...n] Vdc controller integral-action time (control)
- p1252[0...n] Vdc controller derivative-action time (control)
- p1254 Vdc_max controller automatic detection ON level (control)
- p1256[0...n] Vdc_min controller response (kinetic buffering) (control)
- p1257[0...n] Vdc_min controller speed threshold (controller)
- r1258 CO: Vdc controller output (control)

3.2.10 Current setpoint filter

Description

The two current setpoint filters connected in series can be parameterized as follows:

- Low-pass 2nd order (PT2): -40dB/decade
- General filter 2nd order
Band-stop and low-pass with reduction are converted to the parameters of the general filter 2nd order via STARTER.
 - Bandstop
 - Low-pass with reduction by a constant value

The phase frequency curve is shown alongside the amplitude log frequency curve. A phase shift results in a control system delay and should be kept to a minimum.

Overview of important parameters (refer to the List Manual)

- p1655 CI: Current setpoint filter natural frequency tuning
- p1666 Current setpoint filter 2 numerator damping

Function diagram overview (refer to the List Manual)

- 6710 Current setpoint filter

3.2.11 Motor data identification and rotating measurement

Description

Two motor identification options, which are based on each other, are available:

- Standstill measurement with p1910 (motor identification)
- Rotating measurement with p1960 (determining the saturation characteristic)

These can be selected more easily via p1900. 1900 = 2 selects the standstill measurement (motor not rotating). p1900 = 1 also activates the rotating measurement; p1900 = 1 sets p1910 = 1 and p1960 in accordance with the current control type (p1300).

If a permanent-magnet synchronous motor is being used (p0300 = 2), then with p1900 > 1, the encoder adjustment (p1990 = 1) is automatically activated. The technique used can be set in p1980 (also refer to Subsection 3.2.13).

Parameter p1960 is set depending on p1300:

- p1960 = 1, when p1300 = 20 or 22 (without encoder)
- p1960 = 2, when p1300 = 21 or 23 (with encoder)

The measurements, parameterized using p1900 are started in the following sequence after the drive has been enabled:

- Standstill (static) measurement – after the measurement has been completed, the pulses are inhibited and parameter 1910 is reset to 0.
- Encoder adjustment – after the measurement has been completed, the pulses are inhibited and parameter 1990 is reset to 0.
- Rotating measurement – after the measurement has been completed, the pulses are inhibited and parameter 1960 is reset to 0.
- After all of the measurements, activated using p1900 have been successfully completed, then this is set to 0.

Note

To set the new controller setting permanently, the data must be saved in a non-volatile memory (see also "Parameters").



Danger

During motor identification, the drive may cause the motor to move. The emergency OFF functions must be fully operational during commissioning. To protect the machines and personnel, the relevant safety regulations must be observed.

Standstill measurement (p1910)

Motor identification with p1910 is used for determining the motor parameters at standstill (see also p1960: speed controller optimization):

- Equivalent circuit diagram data p1910 = 1
- Magnetizing characteristic p1910 = 3 (functionality is being prepared for permanent-magnet synchronous motors)

For control engineering reasons, you are strongly advised to carry out motor identification because the equivalent circuit diagram data, motor cable resistance, IGBT on-state voltage, and compensation for the IGBT lockout time can only be estimated if the data on the type plate is used. For this reason, the stator resistance for the stability of sensorless vector control or for the voltage boost in the V/f curve is very important. Motor identification is essential if long supply cables or third-party motors are used. When motor data identification is started for the first time, the following data is determined with p1910 on the basis of the data on the type plate (rated data):

Table 3-18 Data determined using p1910

	Induction motor	Permanent-magnet synchronous motor
p1910 = 1	<ul style="list-style-type: none"> • Stator resistance (p0350) • Rotor resistance (p0354) • Stator leakage inductance (p0356) • Rotor leakage inductance (p0358) • Magnetizing inductance (p0360) • Drive converter valve threshold voltage (p1825) • Drive converter valve interlocking times (p1828 ... p1830) 	<ul style="list-style-type: none"> • Stator resistance (p0350) • Stator resistance q axis (p0356) • Stator inductance d axis (p0357) • Drive converter valve threshold voltage (p1825) • Drive converter valve interlocking times (p1828 ... p1830)
p1910 = 3	<ul style="list-style-type: none"> • Saturation characteristics (p0362 ... p0366) 	Not recommended

Since the type plate data contains the initialization values for identification, you must ensure that it is entered correctly and consistently to enable the above data to be determined.

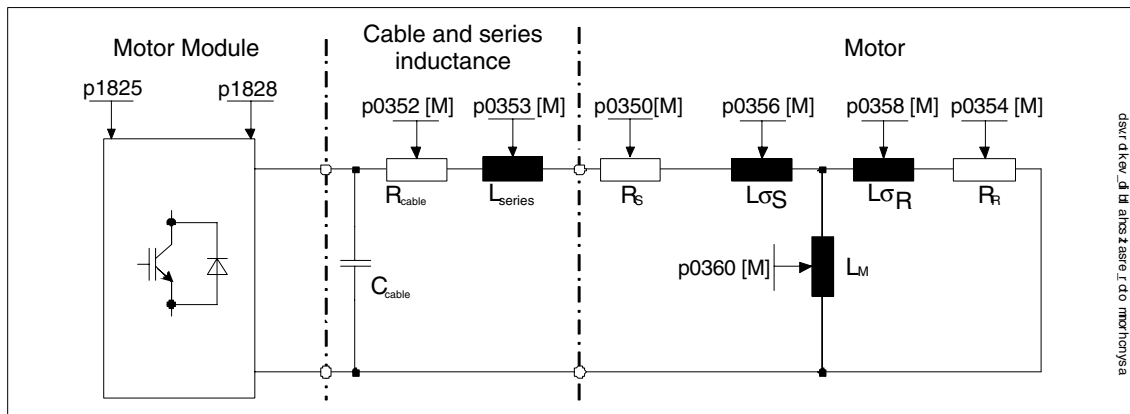


Fig. 3-40 Equivalent circuit diagram for induction motor and cable

In addition to the equivalent circuit diagram data, motor data identification (p1910 = 3) can be used for induction motors to determine the magnetization characteristic of the motor. Due to the higher accuracy, the magnetization characteristic should, if possible, be determined during the rotating measurement (without encoder: p1960 = 1, 3; with encoder: p1960 = 2, 4) If the drive is operated in the field-weakening range, this characteristic should be determined for vector control in particular. The magnetization characteristic can be used to calculate the field-generating current in the field-weakening range more accurately, thereby increasing torque accuracy.

Note

In comparison with the standstill measurement (p1910), for induction motors, the speed controller optimization (p1960) allows the rated magnetization current and saturation characteristic to be determined more accurately.

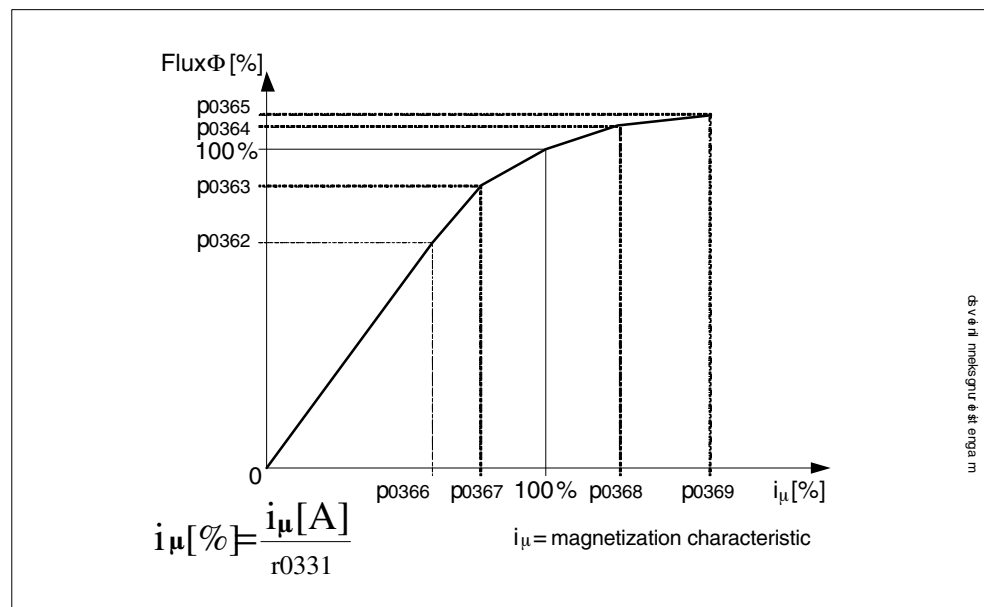


Fig. 3-41 Magnetization characteristic

Note

To set the new controller setting permanently, the data must be saved in a non-volatile memory. Refer to Chapter “Parameters”

Carrying out motor identification

- Enter p1910 > 0. Alarm A07991 is displayed.
- Identification starts when the motor is switched on.
- p1910 resets itself to “0” (successful identification) or fault F07990 is output.

Rotating measurement (p1960)

Different data is identified during the rotating measurement. Speed controller optimization determines the data required (e.g. moment of inertia) for setting the speed controller. Further, for induction motors, the saturation characteristic and rated magnetization current of the motor are measured.

Speed control can be activated via p1960 or p1900 = 1.

If the rotating measurement is not to be carried out using the speed set in p1965, this parameter can be changed before the measurement is started.

The same applies to the speed in p1961 for which the saturation characteristic is determined and the encoder test is carried out.

The speed controller is set to the symmetrical optimum in accordance with dynamic factor p1967. p1967 must be set before the optimization run and only affects the calculation of the controller parameters.

If, during the measurement, it becomes clear that the drive cannot operate in a stable manner with the specified dynamic factor, the dynamic response is reduced automatically and the result displayed in r1968. The drive must also be checked to ensure that it is stable across the entire range. If necessary, the dynamic response may have to be reduced or Kp/Tn adaptation for the speed controller parameterized accordingly.

When commissioning induction machines, you are advised to proceed as follows:

- Before connecting the load, a complete "rotating measurement" (without encoder: p1960 = 1; with encoder: p1960 = 2) should be carried-out. Since the induction machine is idling, you can expect highly accurate results regarding the saturation characteristic and the rated magnetization current.
- When the load is connected, speed controller optimization should be repeated because the total inertia load has changed. This is realized by selecting parameter p1960 (without encoder: p1960 = 3; with encoder: p1960 = 4).

When permanent-magnet synchronous motors are commissioned, with the load connected, the speed controller should be optimized (p1960 = 2/4) (additional information on setting the speed controller, refer to Subsection 3.2.3).

Carrying out the rotating measurement (p1960 > 0):

The following measurements are carried out when the enable signals are set and a switch-on command is issued in accordance with the settings in p1959 and p1960.

- Encoder test
- Only for induction motors:
 - Measurement of the saturation characteristic (p0362 to p0369)
 - Measurement of the magnetization current (p0320) and determination of the offset voltage of the converter for offset compensation (p1774 and p1775)
- Speed controller optimization
 - p1470 and p1472, when p1960 = 1 (operation without encoder)
 - p1460 and p1462, when p1960 = 2 (operation with encoder)
 - Kp adaptation switch-off
- Acceleration pre-control setting (p1496)
- Setting for ratio between the total moment of inertia and that of the motor (p0342)

Note

To set the new controller setting permanently, the data must be saved in a non-volatile memory. Refer to Chapter "Parameters"



Danger

During speed controller optimization, the drive triggers movements in the motor that can reach the maximum motor speed. The emergency OFF functions must be fully operational during commissioning. To protect the machines and personnel, the relevant safety regulations must be observed.

Overview of important parameters (refer to the List Manual)

- p1300[0...n] Open-loop/closed-loop control operating mode
- p1900 Motor data identification and rotating measurement
- p1900 Speed controller optimization configuration

Rotating measurement

- p1959 Speed controller optimization configuration
- p1960 Rotating measurement selection
- p1961 Saturation characteristic speed for calculation
- p1965 Speed controller optimization speed
- p1967 Speed controller optimization dynamics factor
- r1968 Speed controller optimization dynamic factor current
- r1969 Speed controller optimization inertia identified
- r1973 Speed controller optimization encoder test pulse number determined
- p1980 Pole position identification technique
- p1990 Encoder adjustment selection

Motor data identification at standstill

- p1909[0...n] Motor data identification control word
- p1910 Motor data identification selection

3.2.12 Efficiency optimization

Description

The following can be achieved when optimizing the efficiency using p1580:

- Lower motor losses in the partial load range
- Noise in the motor is minimized

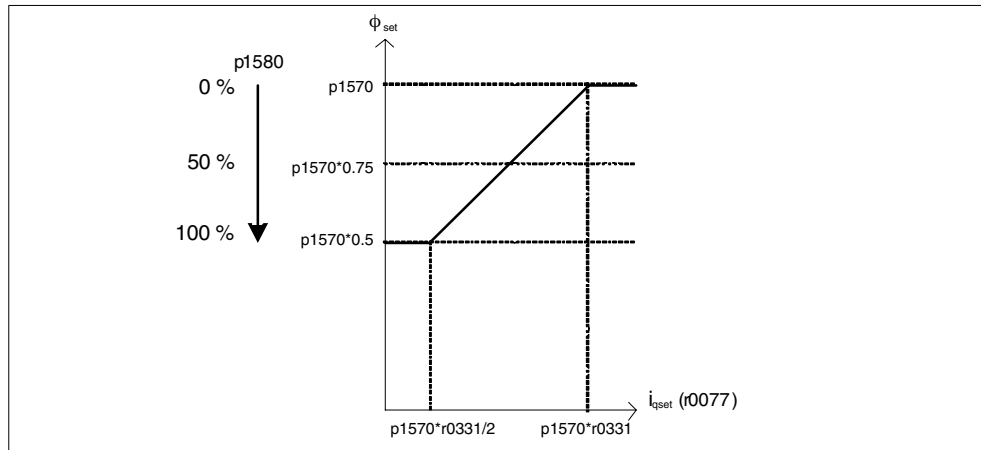


Fig. 3-42 Efficiency optimization

It only makes sense to activate this function if the dynamic response requirements of the speed controller are low (e.g. pump and fan applications).

For p1580 = 100 %, the flux in the motor under no-load operating conditions is reduced to half of the setpoint (reference flux) ($p1570/2$). As soon as load is connected to the drive, the setpoint (reference) flux linearly increases with the load and at approx. $r0077 = r0331 * p1570$ reaches the setpoint set in p1570.

In the field-weakening mode, the final value is reduced by the actual degree of field weakening. The smoothing time (p1582) should be set to approx. 100 to 200 ms. The flux differentiation (also refer to p1401.1) is automatically de-activated internally after magnetization.

Overview of important parameters (refer to the List Manual)

- r0077 CO: Current setpoints, torque-generating
- r0331 Motor magnetizing current/short-circuit current (actual)
- p1570 CO: Flux setpoint
- p1580 Efficiency is optimization

Function diagrams (refer to the List Manual)

- 6722 Field weakening characteristic, Id setpoint (ASM, p0300 = 1)
- 6723 Field weakening control, flux control for induction motors (p0300 = 1)

3.2.13 Automatic encoder adjustment

Description

The pole wheel-oriented closed-loop control of the synchronous motor requires information about the pole wheel position angle. Automatic encoder adjustment must be used if the pole wheel position encoders are not mechanically adjusted and after a motor encoder has been replaced.

Automatic encoder adjustment only makes sense for encoders with absolute position information and/or zero mark. The following encoders are supported:

- Encoder with C/D track
- Resolver
- Absolute encoder (e.g. EnDat, SSI)
- Incremental encoder with zero mark

Encoder adjustment using a zero mark

If an incremental encoder with zero mark is being used, after the zero mark has been passed, the position of the zero mark can be calibrated. Commutation with the zero mark is activated via p0404.15.

Commissioning

Automatic encoder adjustment is activated with p1990 = 1. When the pulses are enabled the next time, the measurement is carried-out and the angular difference determined (p1984) is entered into p0431. For p1990 = 2 the determined angular difference (p1984) is not entered into p0431 and has not effect on the closed-loop motor control. Using this function, the angular difference – entered into p0431 – can be checked. For extremely high moments of inertia, the run time can be scaled higher using p1999.



Warning

The measurement causes the motor to rotate. The motor turns through a minimum of one complete revolution.

Integration

Automatic encoder adjustment is integrated into the system in the following way:

Overview of important parameters:

- p0404.15 Commutation with zero mark
- p0431 Commutation angle offset
- p1990 Encoder adjustment selection
- p1999 Angular commutation offset calibration, scaling

3.2.14 Pole position identification

Description

The pole position identification routine is used to determine the pole position.

3 pole position identification techniques can be selected:

- p1980 = 1, voltage pulsing, first harmonic
This technique also functions for magnetically isotropic motors if adequate iron saturation can be achieved.
- p1980 = 4, voltage pulsing, two-stage
This technique functions with motors that are magnetically anisotropic. During the measurement, the motor must be at a standstill. The measurement is carried-out the next time that the pulses are enabled.

Note

Using this type of identification, the motor can emit a significant amount of noise.

- p1980 = 10, DC current impression
This technique functions for all motors; however, it takes more time than the measurement selected using p1980 = 4. During the measurement, the motor must be able to rotate. The measurement is carried-out the next time that the pulses are enabled. For extremely high moments of inertia, the run time can be scaled higher using p1999.

Integration

The pole position identification is integrated into the system as follows:

Overview of important parameters:

- p0325 Motor pole position identification current 1st phase
- p0329 Motor pole position identification current
- p1780.6 Selects pole position identification PEM without an encoder (sensorless)
- p1980 Pole position identification technique
- p1982 Pole position identification technique
- r1984 Pole position identification angle difference
- r1985 Pole position identification saturation curve
- r1987 Pole position identification trigger curve
- p1999 Angular commutation offset calibration, scaling

3.3 Vector V/f control (r0108.2 = 0)

The simplest solution for a control procedure is the V/f curve, whereby the stator voltage for the induction motor or synchronous motor is controlled proportionately to the stator frequency. This method has proved successful in a wide range of applications with low dynamic requirements, such as:

- Pumps and fans
- Belt drives

and other similar processes.

V/f control aims to maintain a constant flux ϕ in the motor, whereby the flux is proportionate to the magnetization current I_μ or the ratio of voltage (U) to frequency (f).

$$\phi \sim I_\mu \sim U/f$$

The torque (M) generated by the induction motors is, in turn, proportionate to the product (or, more precisely, the vector product $\phi \times I$) of the flux and current.

$$M \sim \phi \times I$$

To generate as much torque as possible with a given current, the motor must function using the greatest possible constant flux. To maintain a constant flux (ϕ), therefore, the voltage (V) must also be changed in proportion to the frequency (f) to ensure a constant magnetization current (I_μ). V/f characteristic control is derived from these basic premises.

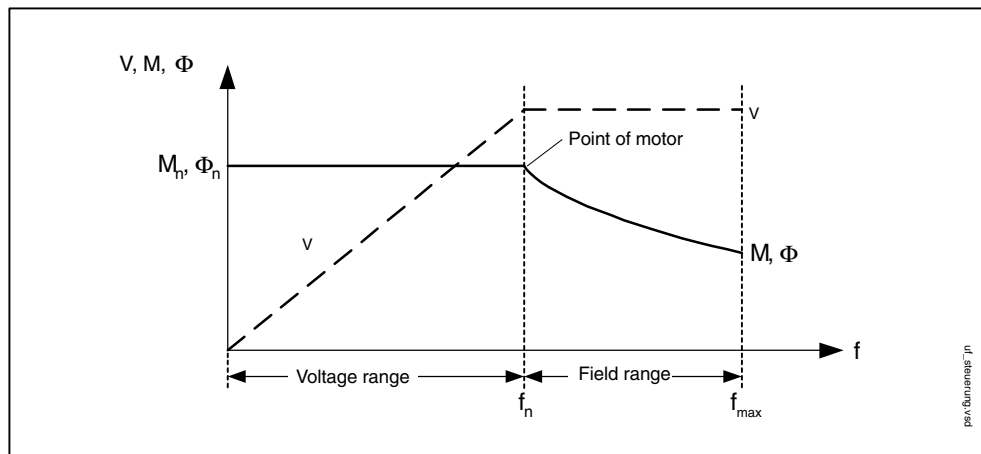


Fig. 3-43 Operating areas and characteristic curves for the induction motor with converter supply

Several variations of the V/f characteristic exist, which are shown in the following table.

Table 3-19 V/f characteristic (p1300)

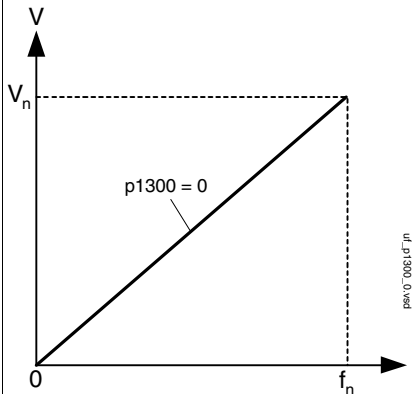
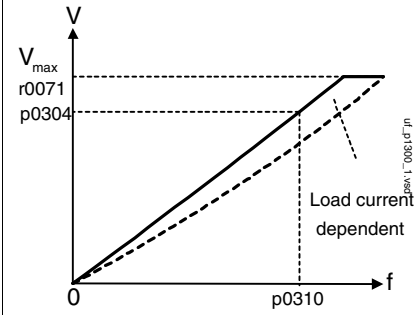
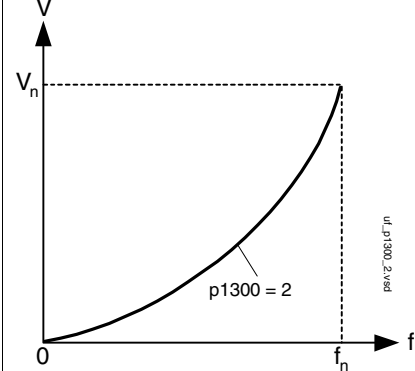
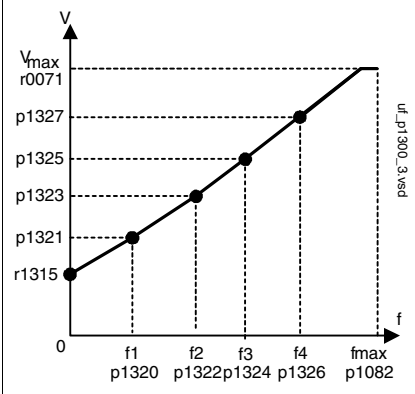
Parameter values	Meaning	Application / property
0	Linear characteristic	Standard (w/o voltage boost) 
1	Linear characteristic with flux current control (FCC)	Characteristic that compensates for voltage drops in the stator resistance for static / dynamic loads (flux current control FCC). This is particularly useful for small motors, since they have a relatively high stator resistance. 
2	Parabolic characteristic	Characteristic that takes into account the motor torque characteristic (e.g. fan/pump). a) Quadratic characteristic (n ² characteristic) b) Energy saving because the low voltage also results in small currents and drops. 
3	Programmable characteristic	Characteristic that takes into account the motor / machine torque characteristic (e.g. synchronous motor). 

Table 3-19 V/f characteristic (p1300), continued

Parameter values	Meaning	Application / property
5	Precise frequency drives	Characteristic that takes into account the technological particularity of an application (e.g. textile applications): a) whereby current limitation (I _{max} controller) only affects the output voltage and not the output frequency, or b) by disabling slip compensation
6	Precise frequency drives with flux current control (FCC)	Characteristic that takes into account the technological particularity of an application (e.g. textile applications): a) whereby current limitation (I _{max} controller) only affects the output voltage and not the output frequency, or b) by disabling slip compensation Voltage drops in the stator resistance for static/dynamic loads are also compensated (flux current control FCC). This is particularly useful for small motors, since they have a relatively high stator resistance.
19	Independent voltage setpoint	The user can define the output voltage of the Motor Module independently of the frequency using BICO parameter p1330 via the interfaces (e.g. analog input AI0 of a terminal board 30 → p1330 = r4055[0]).

3.3.1 Voltage boost

With an output frequency of 0 Hz, the V/f characteristics yield an output voltage of 0 V. The voltage boost must be entered to:

- Magnetize the induction motor.
- Maintain the load.
- Compensate for the losses (ohmic losses in the winding resistors) in the system
- Generate a breakaway/acceleration/braking torque.

The voltage boost can be increased permanently (p1310) or during acceleration (p1311).

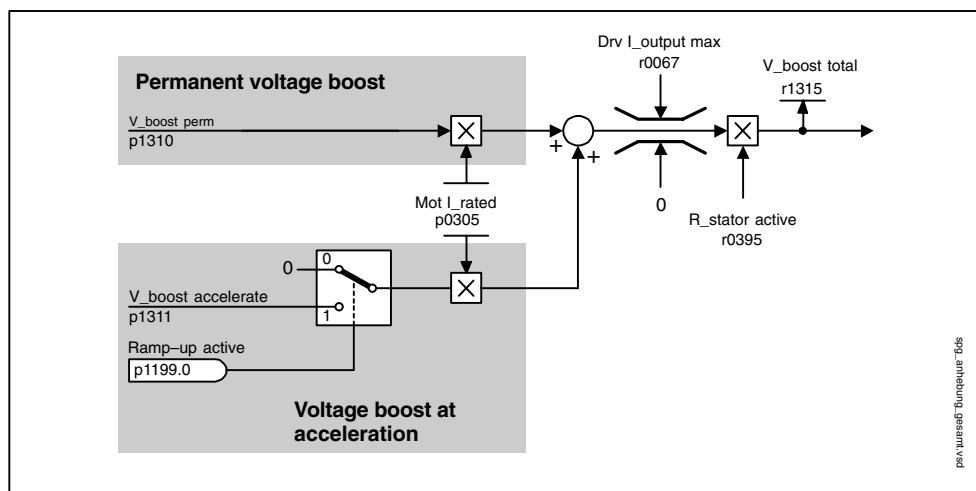


Fig. 3-44 Voltage boost total

Note

The voltage boost affects all V/f characteristics (p1300).

Notice

If the voltage boost value is too high, this can result in a thermal overload of the motor winding.

Permanent voltage boost (p1310)

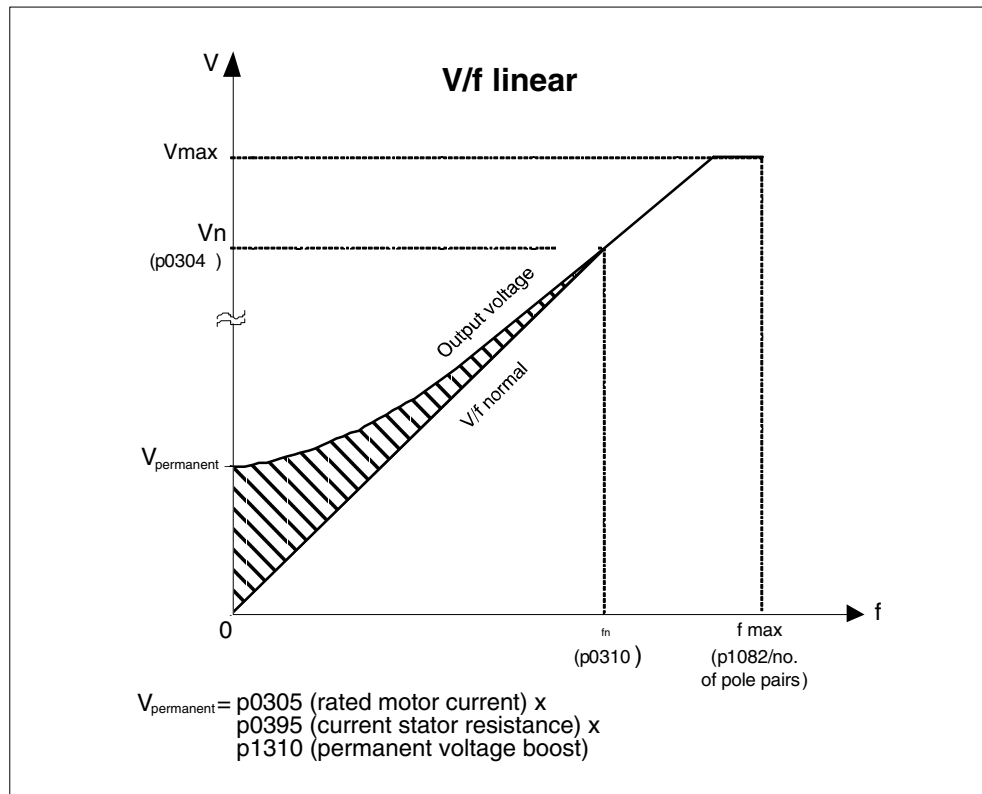


Fig. 3-45 Permanent voltage boost (example: p1300 and p1310 = 0)

Voltage boost at acceleration (p1311)

The voltage boost when accelerating is effective if the ramp-function generators provide the feedback signal "ramp-up active" (1199.0 = 1)

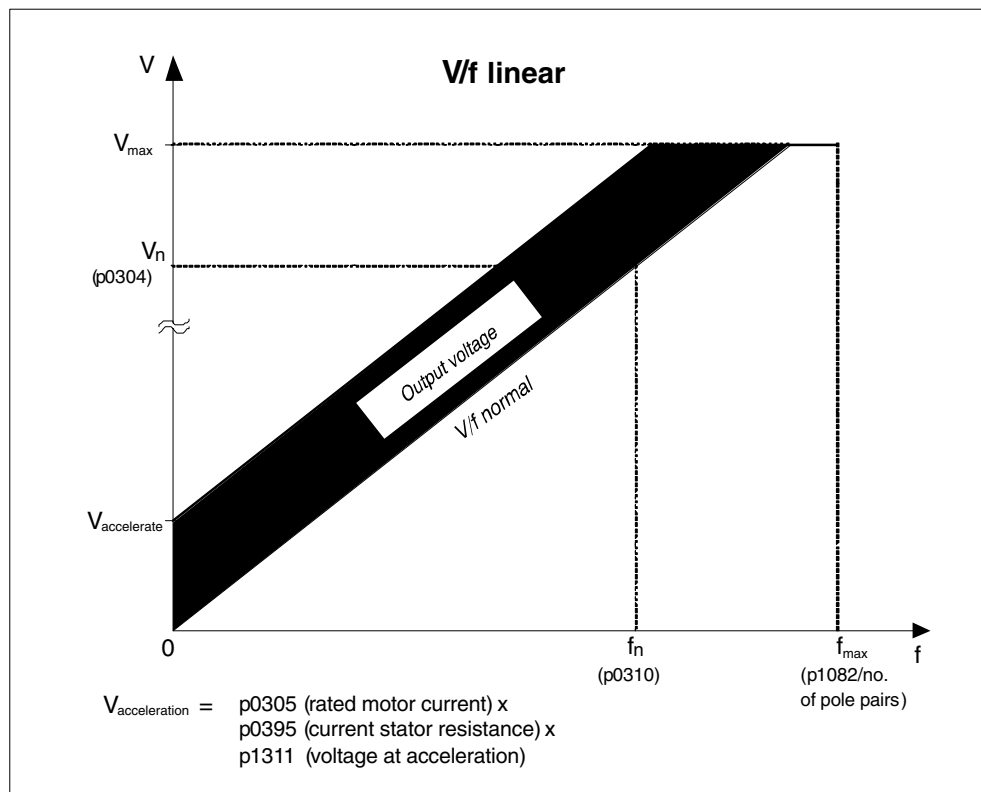


Fig. 3-46 Voltage boost at acceleration (example: p1300 and p1311 = 0)

Function diagram for voltage boost (see List Manual)

- 6300 V/f characteristic and voltage boost

Parameters for voltage boost (see List Manual)

- p0304[0...n] Rated motor voltage
- p0305[0...n] Rated motor current
- p0395[0...n] Stator resistance current
- p1310[0...n] Voltage boost permanent
- p1311[0...n] Voltage boost at acceleration
- r1315 Voltage boost total

3.3.2 Slip compensation

Description

Slip compensation is an additional V/f control function. It ensures that the speed of induction motors is maintained at a constant level irrespective of the load.

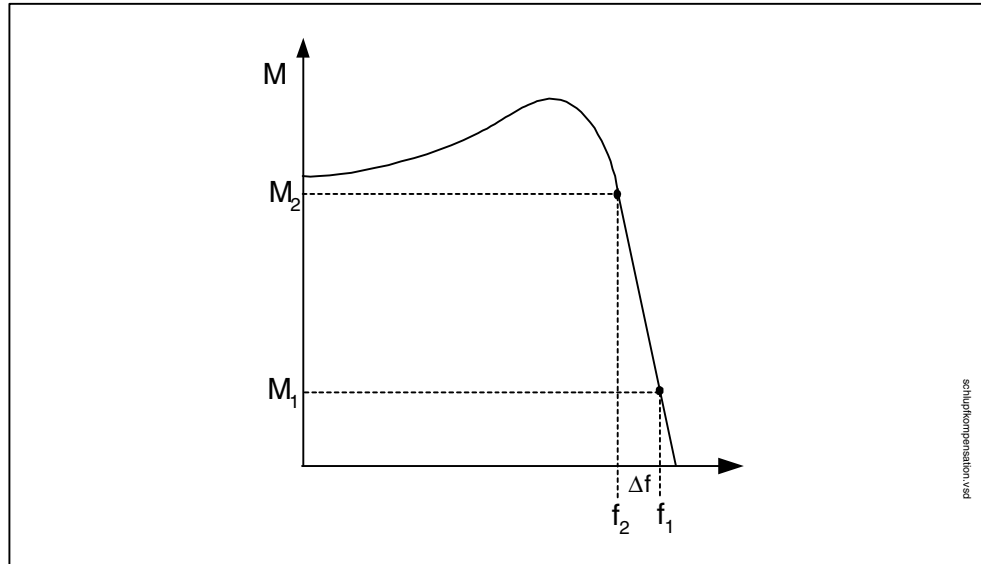


Fig. 3-47 Slip compensation

Overview: important parameters for slip compensation

- p1335[0...n] Slip compensation
 - p1335 = 0.0 %: slip compensation is deactivated.
 - p1335 = 100.0 %: slip is fully compensated.
- p1336[0...n] Slip compensation limit value
- r1337[0...n] Slip compensation actual value

3.3.3 Vdc control

Description

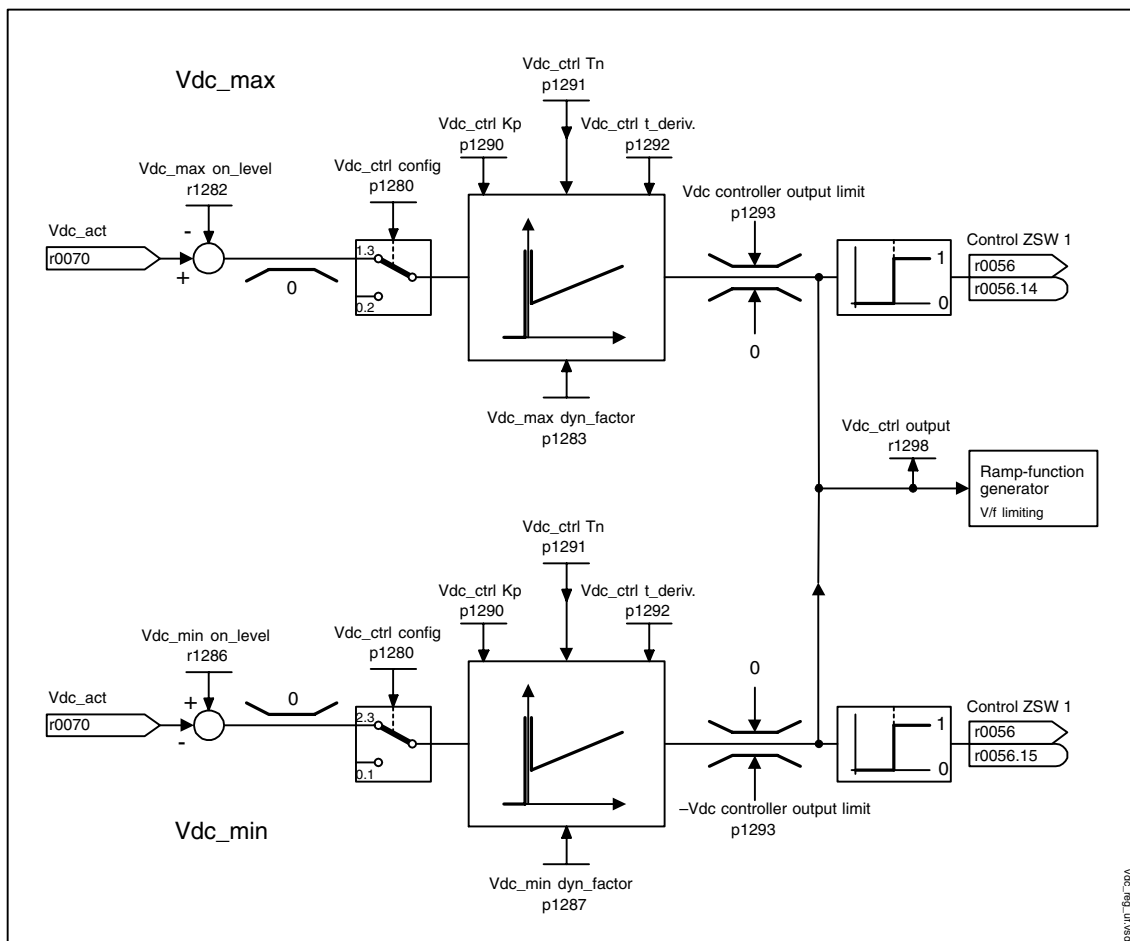


Fig. 3-48 Vdc control V/f

The “Vdc control” function can be activated using the appropriate measures if an overvoltage or undervoltage is present in the DC link.

- Overvoltage in the DC link
 - Typical cause

The drive is operating in regenerative mode and is supplying too much energy to the DC link.
 - Remedy

Reduce the regenerative torque to maintain the DC link voltage within permissible limits.
- Undervoltage in the DC link
 - Typical cause

Failure of the supply voltage or supply for the DC link.

– Remedy

Specify a regenerative torque for the rotating drive to compensate the existing losses, thereby stabilizing the voltage in the DC link (kinetic buffering).

Properties

- Vdc control
 - This comprises Vdc_max control and Vdc_min control (kinetic buffering), which are independent of each other.
 - Joint PI controller. The dynamic factor is used to set Vdc_min and Vdc_max control to a smoother or harder setting independently of each other.
- Vdc_min control (kinetic buffering)
 - With this function, the kinetic energy of the motor is used for buffering the DC link voltage in the event of a momentary power failure, thereby delaying the drive.
- Vdc_max control
 - This function can be used to control momentary regenerative load without shutdown with “overvoltage in the DC link“.
 - Vdc_max control is only recommended with a supply without active closed-loop control for the DC link and without feedback.

Description of Vdc_min control

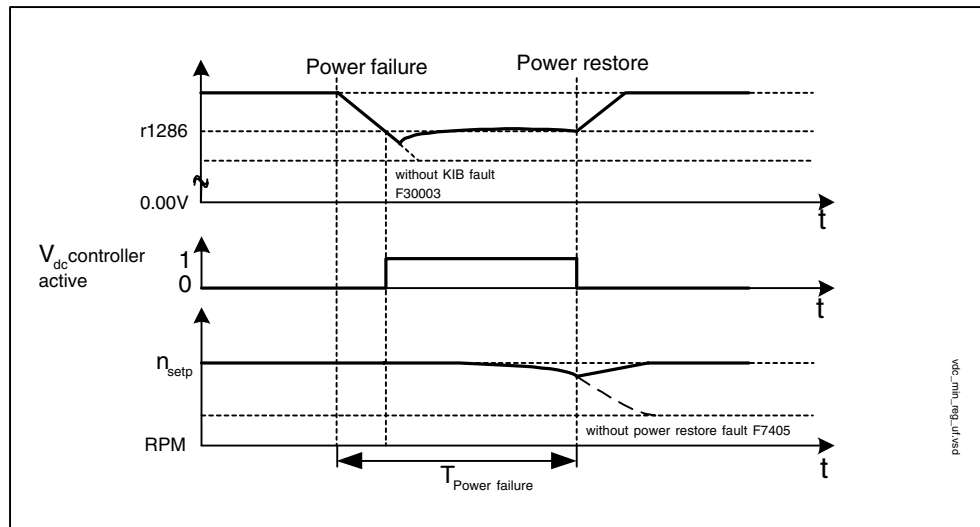


Fig. 3-49 Switching Vdc_min control on/off (kinetic buffering)

In the event of a power failure, Vdc_min control is activated when the Vdc_min switch-in level is undershot. This controls the DC link voltage and maintains it at a constant level. The motor speed is reduced.

When the power supply is restored, the DC link voltage increases again and Vdc_min control is deactivated at 5 % above the Vdc_min switch-on level. The motor continues operating normally.

If the power supply is not reestablished, the motor speed continues to drop. When the threshold in p1257 is reached, this results in a response in accordance with p1256.

Once the time threshold (p1255) has elapsed without the line voltage being reestablished, a fault is triggered (F07406), which can be parameterized as required (factory setting: OFF3).

Note

You must make sure that the converter is not disconnected from the power supply. It could become disconnected, for example, if the line contactor drops out. The line contactor should have an uninterruptible power supply (UPS), for example.

Description of Vdc_max control

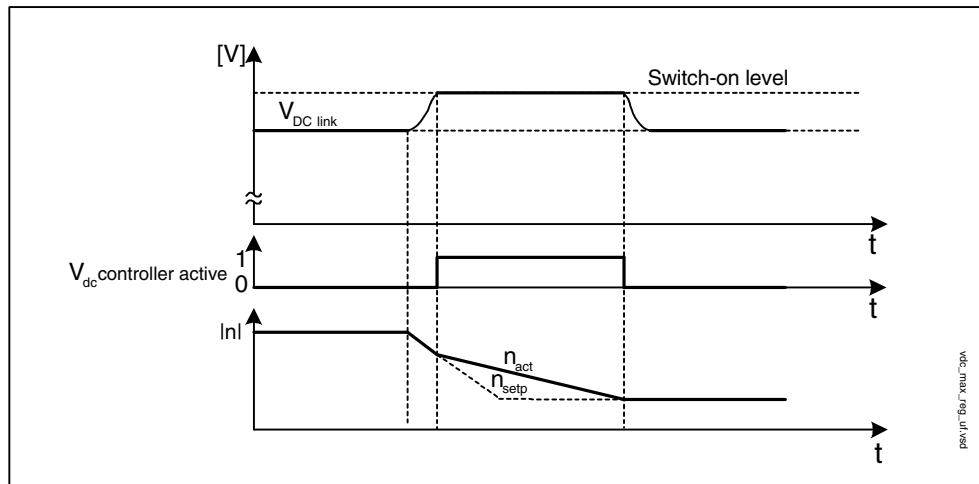


Fig. 3-50 Switching Vdc_max control on/off

The switch-in level for Vdc_max control (r1282) is calculated as follows:

- Automatic detection of ON level deactivated (p1294 = 0)
 $r1282 = 1.15 * p0210$ (device supply voltage)
- Automatic detection of ON level activated (p1294 = 1)
 $r1282 = Vdc_max - 50 \text{ V}$ (Vdc_max: overvoltage threshold of the Motor Module)

Function diagram for Vdc controller (see List Manual)

- 6320 Vdc_max controller and Vdc_min controller

Overview: important parameters for the Vdc controller (see List Manual)

- p1280[0...n] Vdc controller configuration (V/f)
- r1282 Vdc_max controller switch-in level (V/f)
- p1283[0...n] Vdc_max controller dynamic factor (V/f)
- p1285[0...n] Vdc_min controller switch-in level (kinetic buffering) (V/f)
- r1286 Vdc_min controller switch-in level (kinetic buffering) (V/f)
- p1287[0...n] Vdc_min controller dynamic factor (kinetic buffering) (V/f)
- p1290[0...n] Vdc controller proportional gain (V/f)
- p1291[0...n] Vdc controller integral action time (V/f)
- p1292[0...n] Vdc controller derivative action time (V/f)
- p1293 Vdc controller output limit (V/f)
- p1294 Vdc_max controller automatic detection ON signal level (V/f)
- p1295 Vdc_min controller time threshold (V/f)
- p1296[0...n] Vdc_min controller response (kinetic buffering) (V/f)
- p1297[0...n] Vdc_min controller speed threshold (V/f)
- r1298[0...n] CO: Vdc controller output (V/f)

3.4 Information on commissioning vector motor types

Equivalent circuit diagram for vector induction motor and cable

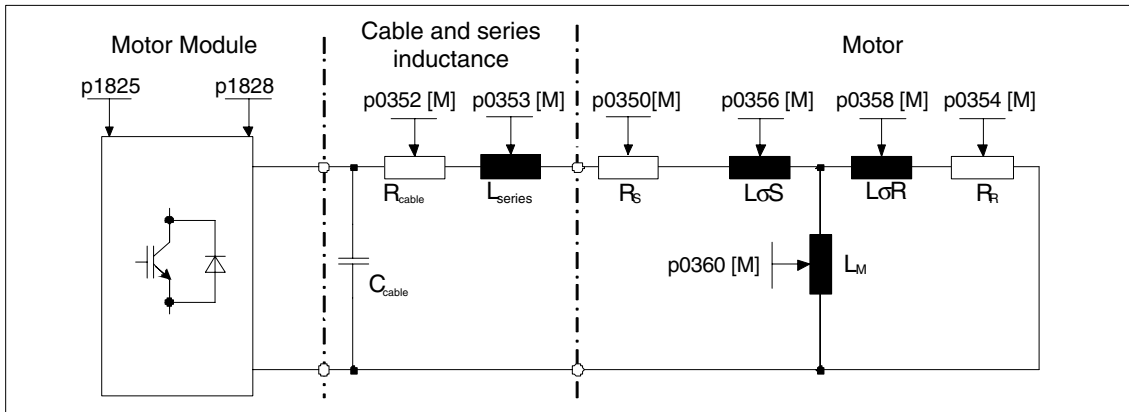


Fig. 3-51 Equivalent circuit diagram for induction motor and cable

Equivalent circuit diagram for vector synchronous motor and cable

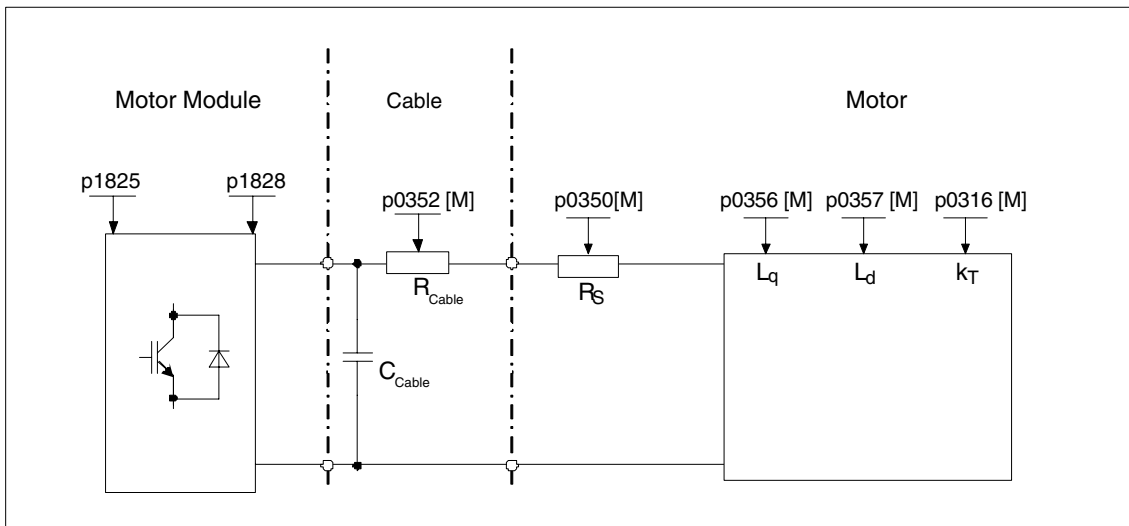


Fig. 3-52 Equivalent circuit diagram for vector synchronous motor and cable

Induction motors, rotating

The following parameters can be entered in STARTER during the commissioning phase:

Table 3-20 Motor data, rating plate

Parameter	Description	Comments
p0304	Rated motor voltage	If this value is not known, then a "0" can also be entered. Using this value, the stator leakage inductance can be more precisely calculated (p0356, p0357).
p0305	Rated motor current	–
p0307	Rated motor power	–
p0308	Rated motor power factor	–
p0310	Rated motor frequency	–
p0311	Motor rated speed	–
p0335	Motor cooling type	–

The following parameters can be optionally entered:

Table 3-21 Optional motor data

Parameter	Description	Comments
p0320	Motor rated magnetization current/short-circuit current	–
p0322	Maximum motor speed	–
p0341	Motor moment of inertia	–
p0342	Moment of inertia, ratio total to	–
p0344	Motor weight	–
p0350	Motor stator resistance, cold	–
p0352	Cable resistance (component of the stator resistance)	–
p0354	Motor rotor resistance, cold	–
p0356	Motor stator inductance	–
p0358	Motor rotor leakage inductance	–
p0360	Motor magnetizing inductance	–
p0640	Current limit	This value is limited to a maximum of $4 * p0305$. The value is pre-assigned with $1.5 * p0305$ during commissioning.
p1080	Minimum speed	–

Table 3-21 Optional motor data, continued

Parameter	Description	Comments
p1082	Maximum rotational speed	This value can be less than or equal to p0322.
p1120	Ramp-function generator ramp-up time	–
p1121	Ramp-function generator ramp-down time	–
p1135	OFF3 ramp-down time	–

Permanent-magnet synchronous motors, rotating

Permanent-magnet synchronous motors that have a position encoder are supported.

Typical applications include, for example, direct drives with torque motors; these distinguish themselves as a result of the high torque at low speeds. Using these drives, in appropriate applications, gearboxes and therefore mechanical parts subject to wear can be eliminated.

Temperature protection can be implemented using a temperature sensor (KTY/PTC). In order to achieve a high torque accuracy, we recommend that a KTY temperature sensor is used.



Warning

A voltage is generated as soon as the motor rotates. When working on the drive converter, the motor must safely be disconnected and locked-out. If this is not possible, then the motor must be mechanically locked e.g. using a holding brake.

Features

- Field weakening up to approx. 1.2 * rated speed (this depends on the drive converter supply voltage and the motor data, also refer to limitations/constraints)
- Flying restart
- Vector closed-loop speed and torque control
- Vector V/f control for diagnostics
- Motor identification
- Automatic rotating encoder adjustment (the zero encoder position is calibrated)
- Speed controller optimization (rotating measurement)
- Thermal protection via temperature sensor (PTC/KTY)
- All encoders that can be connected to an SMC10 or SMC20 are supported.

General conditions

- Maximum speed and maximum torque depend on the available drive converter output voltage and the motor counter voltage (calculation rules: EMF may not exceed V_{rated} drive converter)
- Calculating the maximum speed:

$$n_{max} = V_{nom,AC} * \frac{\sqrt{3} * 30}{k_T * \pi}$$

Calculating k_T refer to the section on commissioning

- The maximum torque – as a function of the terminal voltage and load duty cycle can be taken from the motor data sheets/Configuration Manuals.

Commissioning

We recommend the following points when commissioning:

- Commissioning Wizard in STARTER

The motor identification routine and the “rotating measurement” (p1900) can be activated from the commissioning Wizard in STARTER. The encoder adjustment (p1990) is automatically activated together with the motor identification routine.

- Motor identification (standstill (static) measurement (p1910))

Further information: See Subsection 3.2.11

- Encoder adjustment (p1990)

Further information: See Subsection 3.2.13



Warning

When commissioning the system for the first time and when replacing an encoder, the encoder must be adjusted (p1990).

- Rotating measurement (p1960)

Further information: See Subsection 3.2.11

The following parameters can be entered in STARTER during the commissioning phase:

Table 3-22 Motor data

Parameter	Description	Comments
p0304	Rated motor voltage	If this value is not known, then a "0" can also be entered. Using this value, the stator leakage inductance can be more precisely calculated (p0356, p0357).
p0305	Rated motor current	–
p0311	Rated motor speed	–
p0314	Motor pole pair number	–
p0316	Motor torque constant	–

If the torque constant k_T is not stamped on the rating plate or specified in the data sheet, then you can calculate this value from the rated motor data or from the stall current I_o and stall torque M_o as follows:

$$k_T = \frac{M_N}{I_N} = \frac{60 \frac{s}{min} * P_N}{2\pi * n_N * I_N} \text{ or}$$

$$k_T = \frac{M_o}{I_o}$$

Table 3-23 Optional data

Parameter	Description	Comments
p0320	Motor rated magnetization current/short-circuit current	This is used for the field weakening characteristic
p0322	Maximum motor speed	Maximum mechanical speed
p0323	Maximum motor current	De-magnetization protection
p0328	PE spindle, reluctance torque constant	–
p0341	Motor moment of inertia	For speed controller pre-control
p0342	Ratio between the total and motor moment of inertia	–
p0344	Motor weight	For a thermal motor model – not relevant for synchronous motors
p0350	Motor stator resistance, cold	–
p0356	Motor stator inductance Lq	–
p0357	Motor stator inductance Ld	–

Table 3-23 Optional data, continued

Parameter	Description	Comments
p0640	Current limit	This value is limited to a maximum of $4 * p0305$. The value is pre-assigned with $1.5 * p0305$ during commissioning.
p1080	Minimum speed	–
p1082	Maximum rotational speed	This value can be less than or equal to p0322.
p1120	Ramp-function generator ramp-up time	–
p1121	Ramp-function generator ramp-down time	–
p1135	OFF3 ramp-down time	–

This optional motor data, if they are known, can be entered. Otherwise, they are estimated using the rating plate data or are determined using a motor identification routine or speed controller optimization.



Notes

Extended Functions

4

4.1 “Technology controller” function module

4.1.1 Features

Simple control functions can be implemented with the technology controller, e.g.:

- Level control
- Temperature control
- Dancer position control
- Pressure control
- Flow control
- Simple closed-loop control without higher-level controller
- Tension control

The technology controller features:

- Two scalable setpoints
- Scalable output signal
- Separate fixed values
- Separate motorized potentiometer
- The output limits can be activated and deactivated via the ramp-function generator.
- The D component can be switched to the control deviation or actual value channel.
- The motorized potentiometer of the technology controller is only active when the drive pulses are enabled.

4.1.2 Integration

The technology controller function is integrated in the system as follows.

Function diagram overview (refer to the List Manual)

- 7950 Fixed values (r0108.16 = 1)
- 7954 Motorized potentiometer (r0108.16 = 1)
- 7958 Closed-loop control (r0108.16 = 1)

Important parameters (refer to the List Manual)

Fixed setpoints

- p2201[0..n] CO: Technology controller, fixed value 1
- ...
- p2215[0..n] CO: Technology controller, fixed value 15
- p2220[0..n] BI: Technology controller fixed value selection bit 0
- p2221[0..n] BI: Technology controller fixed value selection bit 1
- p2222[0..n] BI: Technology controller fixed value selection bit 2
- p2223[0..n] BI: Technology controller fixed value selection bit 3

Motorized potentiometer

- p2230[0..n] Technology controller motorized potentiometer configuration
- p2235[0..n] BI: Technology controller motorized potentiometer, raise setpoint
- p2236[0..n] BI: Technology controller motorized potentiometer, lower setpoint
- p2237[0..n] Technology controller motorized potentiometer maximum value
- p2238[0..n] Technology controller motorized potentiometer minimum value
- p2240[0..n] Technology controller motorized potentiometer start value
- r2245 CO: Technology controller motorized potentiometer setpoint before RFG
- p2247[0..n] Technology controller motorized potentiometer ramp-up time
- p2248[0..n] Technology controller motorized potentiometer ramp-down time
- r2250 CO: Technology controller motorized potentiometer setpoint after RFG

Closed-loop control

- p2200 BI: Technology controller enable
- p2253[0..n] CI: Technology controller setpoint 1
- p2254 [0..n] CI: Technology controller setpoint 2
- p2255 Technology controller setpoint 1 scaling
- p2256 Technology controller setpoint 2 scaling
- p2257 Technology controller ramp-up time
- p2258 Technology controller ramp-down time
- p2261 Technology controller setpoint filter time constant
- p2263 Technology controller type
- p2264[0..n] CI: Technology controller actual value
- p2265 Technology controller actual value filter time constant
- p2280 Technology controller proportional gain
- p2285 Technology controller integral action time
- p2289[0..n] CI: Technology controller pre-control signal
- p2295 Technology controller output scaling

4.1.3 Description

The technology controller is designed as a PID controller, whereby the differentiator can be switched to the control deviation channel or the actual value channel (factory setting). The P, I, and D components can be set separately. A value of 0 deactivates the corresponding component. Setpoints can be specified via two connector inputs. The setpoints can be scaled via parameters (p2255 and p2256). A ramp-function generator in the setpoint channel can be used to set the setpoint ramp-up/ramp-down time via parameters p2257 and p2258. The setpoint and actual value channel each have a smoothing element. The smoothing time can be set via parameters p2261 and p2265.

The setpoints can be specified via separate fixed setpoints (p2201 to p2215), the motorized potentiometer, or via the field bus (e.g. PROFIBUS).

Pre-control can be integrated via a connector input.

The output can be scaled via parameter p2295 and the control direction reversed. It can be limited via parameters p2291 and p2292 and interconnected as required via a connector output (r2294).

The actual value can be integrated, for example, via an analog input on the TB30.

If a PID controller has to be used for control reasons, the D component is switched to the setpoint/actual value difference (p2263 = 1) unlike in the factory setting. This is always necessary when the D component is to be effective, even if the reference variable changes. The D component can only be activated when p2274 > 0.

4.1.4 Examples

Dancer control

The objective here is to maintain a constant level in the container.

This is carried out by means of a variable-speed pump in conjunction with a sensor for measuring the level.

The level is determined via an analog input (e.g. AI0 on TB30) and sent to the technology controller. The level setpoint is defined in a fixed setpoint. The resulting controlled variable is used as the setpoint for the speed controller.

In this example, terminal board 30 (TB30) is used.

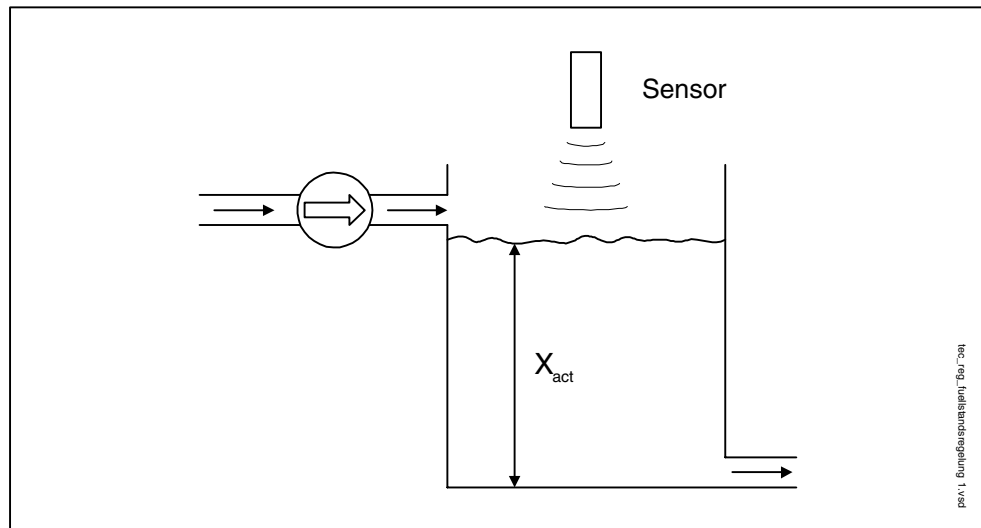


Fig. 4-1 Liquid level control: application

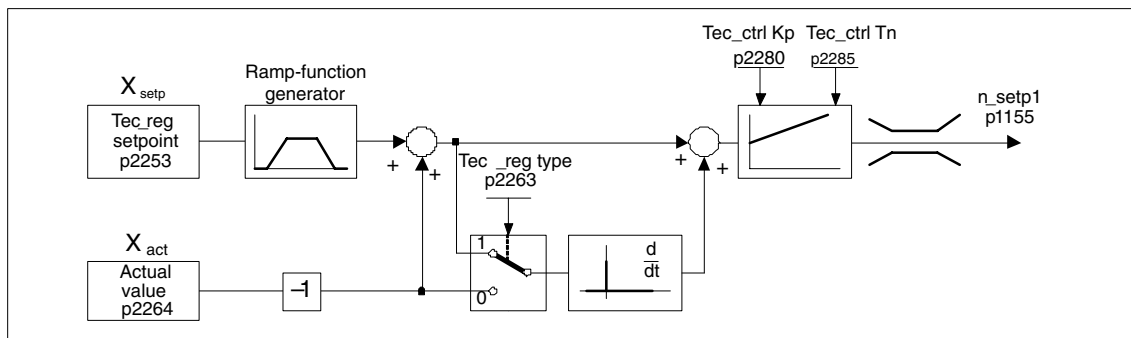


Fig. 4-2 Liquid level control: controller structure

Table 4-1 Key parameters for dancer control

Parameter	Designation	Example
p1055	n_setp1 downstream of RFG	p1055 = r2294 Tec_ctrl output_sig [FP 3080]
p2200	BI: Technology controller enable	p2200 = 1 Technology controller enabled
p2253	CI: Technology controller setpoint 1	p2253 = r2224 Fixed setpoint active [FP 7950]
p2263	Technology controller type	p2263 = 1 D component in fault signal [FP 7958]
p2264	CI: Technology controller actual value (X _{ACTUAL})	p2264 = r4055 [1] Analog input AI1 of TB30
p2280	Technology controller p-gain	p2280 Determine by optimization
p2285	Technology controller integral action time	p2285 Determine by optimization

4.1.5 Commissioning using STARTER

The function module "technology controller" can be activated via the commissioning Wizard or the drive configuration (configure DDS).

You can check the actual configuration in parameter r0108.16.

4.2 “Extended monitoring functions” function module

4.2.1 Features

When the extension is activate, the monitoring functions are extended as follows:

- Speed setpoint monitoring: $ln_setl \leq p2161$
- Speed setpoint monitoring: $n_set > 0$
- Load monitoring

Description of load monitoring

This function monitors power transmission between the motor and the working machine. Typical applications include V-belts, flat belts, or chains that loop around the belt pulleys or cog wheels for drive and outgoing shafts and transfer the peripheral speeds and forces. Load monitoring can be used here to identify blockages in the working machine and interruptions to the power transmission.

During load monitoring, the current speed/torque curve is compared with the programmed speed/torque curve (p2182 to p2190). If the current value is outside the programmed tolerance bandwidth, a fault or alarm is triggered depending on parameter p2181. The fault or alarm message can be delayed by means of parameter p2192 to prevent false alarms caused by brief transitional states.

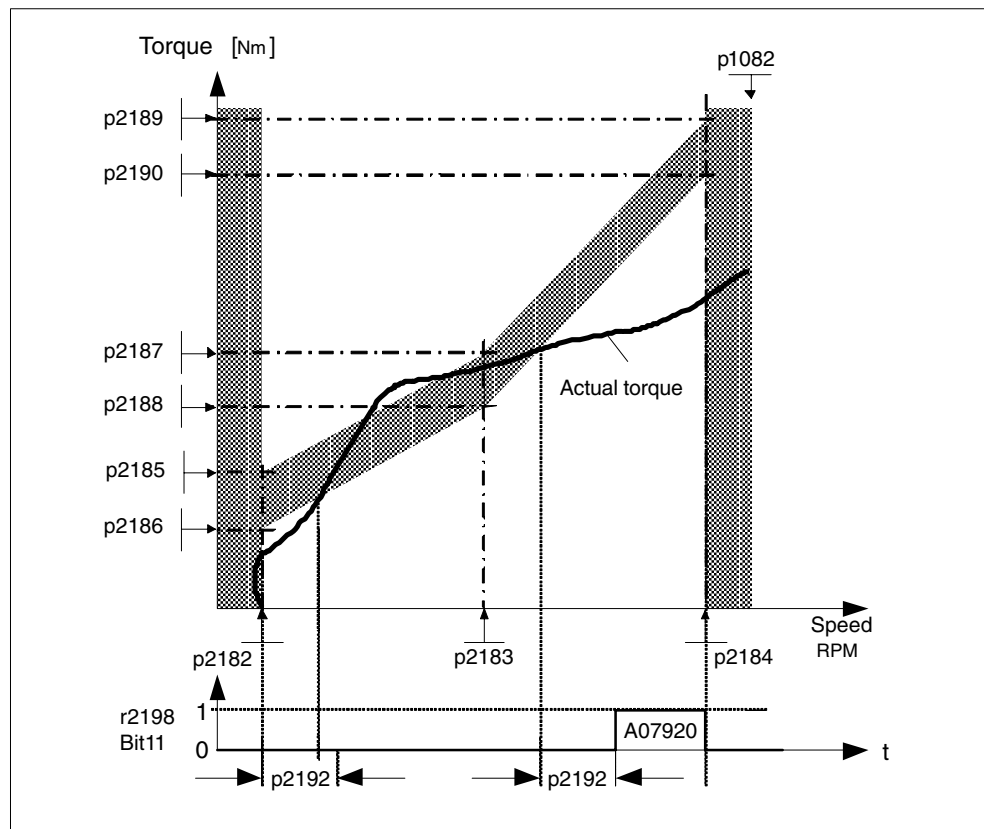


Fig. 4-3 Load monitoring

4.2.2 Integration

The extended monitoring functions are integrated as follows in the system.

Important parameters (refer to the List Manual)

Load monitoring

- p2181[D] Load monitoring response
- p2182[D] Load monitoring speed threshold 1
- p2183[D] Load monitoring speed threshold 2
- p2184[D] Load monitoring speed threshold 3
- p2185[D] Load torque monitoring torque threshold 1 upper
- ...
- p2190[D] Load torque monitoring torque threshold 3 lower
- p2192[D] Load monitoring delay time

Speed setpoint monitoring

- p2150[D] Hysteresis speed 3
- p2151[C] CI: Speed setpoint
- p2161[D] Speed threshold value 3
- r2198.4 BO: STW monitoring 2, In_setpl <= p2161
- r2198.5 BO: STW monitoring 2, n_setp < 0

Function diagram overview (refer to the List Manual)

- 8010 Speed messages
- 8013 Load monitoring

4.2.3 Commissioning

The extended monitoring functions are activated while the commissioning Wizard is running. Parameter r0108.17 indicates whether it has been activated.

4.3 Simple brake control

4.3.1 Features

- Automatic activation by means of sequence control
- Standstill (zero-speed) monitoring
- Forced brake release (p0855, p1215)
- Close the brake for a 1 signal “unconditionally close holding brake” (p0858)
- Application of brake after “Enable speed controller” signal has been removed (p0856)

4.3.2 Integration

The simple brake control function is integrated in the system as follows.

Important parameters (refer to the List Manual)

- r0056.4 Magnetizing complete
- r0060 CO: Speed setpoint before the setpoint filter
- r0063 CO: Actual speed smoothed (servo)
- r0063[0] CO: Actual speed, unsmoothed (vector)
- r0108.14 Extended brake control
- p0855[C] BI: Unconditionally release holding brake
- p0856 BI: Enable speed controller
- p0858 BI: Unconditionally close the holding brake
- r0899.12 BO: Holding brake open
- r0899.13 BO: Command, close holding brake
- p1215 Holding brake configuration
- p1216 Holding brake release time
- p1217 Holding brake application time
- p1226 Threshold for zero speed detection
- p1227 Zero speed detection monitoring time
- p1228 Zero speed detection, delay time

Function diagram overview (refer to the List Manual)

- 2701 Simple brake control (r0108.14 = 0)

4.3.3 Description

The “Simple brake control” function is used exclusively for controlling holding brakes. The holding brake is used to secure drives against unwanted motion when deactivated.

The trigger command for releasing and applying the holding brake is transmitted via DRIVE-CLiQ from the Control Unit, which monitors and logically connects the signals to the system-internal processes, directly to the Motor Module.

The Motor Module then performs the action and activates the output for the holding brake. The sequence control, is shown in detail in the List Manual (FD 2701). The operating principle of the holding brake can be configured via parameter p1215.

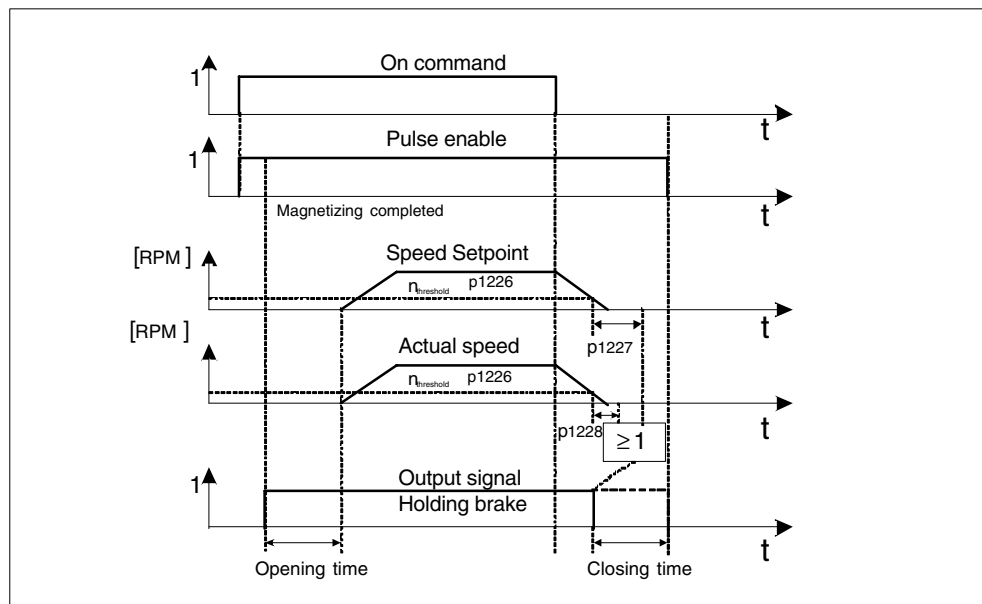


Fig. 4-4 Function chart: simple brake control



Warning

The holding brake must not be used as a working brake.

When holding brakes are used, the special technological and machine-specific conditions and standards for ensuring personnel and machine safety must be observed.

The risks involved with vertical axes, for example, must also be taken into account.

4.3.4 Commissioning

Simple brake control is activated automatically ($p1215 = 1$) if the Motor Module has an internal brake control function and a connected brake has been found.

If the component does not have an internal brake control function, control can be activated via parameter ($p1215 = 3$).

Caution

If $p1215 = 0$ (no brake available) is set when a brake is present, the drive runs with applied brake. This can destroy the brake.

4.4 "Extended brake control" function module

4.4.1 Features

The extended brake control function has the following features:

- Forced brake release (p0855, p1215)
- Close the brake for a 1 signal "unconditionally close holding brake" (p0858)
- Binector inputs for releasing/applying the brake (p1218, p1219)
- Connector input for threshold value for releasing/applying the brake (p1220)
- OR/AND block, each with two inputs (p1279, r1229.10, p1229.11)
- Holding and operational brakes can be activated.
- Function for monitoring brake feedback signals (r1229.4, r1229.5)
- Configurable responses (A7931, A7932)
- Application of brake after "Enable speed controller" signal has been removed (p0856)

4.4.2 Integration

The extended brake control function is integrated in the system as follows.

Important parameters (refer to the List Manual)

- r0108.14 Extended brake control
 - r0899 CO/BO: Status word sequence control
- Standstill (zero-speed) monitoring
- r0060 CO: Speed setpoint before the setpoint filter
 - r0063 CO: Actual speed smoothed (servo)
 - r0063[0] CO: Actual speed, unsmoothed (vector)
 - p1225 CI: Standstill detection, threshold value
 - p1226 Threshold for zero speed detection
 - p1227 Zero speed detection monitoring time
 - p1228 Zero speed detection, delay time
 - p1224[0..3] BI: Close motor holding brake at standstill
 - p1276 Motor holding brake standstill detection bypass

Releasing/applying the brake

- p0855 BI: Unconditionally release holding brake
- p0858 BI: Unconditionally close the holding brake
- p1216 Holding brake release time
- p1217 Holding brake application time
- p1218[0..1] BI: Open motor holding brake
- p1219[0..3] BI: Immediately close motor holding brake
- p1220 CI: Open motor holding brake, signal source, threshold
- p1221 Motor holding brake open threshold
- p1277 Motor holding brake delay braking threshold exceeded

Free modules

- p1279 BI: Motor holding brake, OR/AND logic operation

Brake monitoring functions

- p1222 BI: Motor holding brake, feedback signal, brake closed
- p1223 BI: Motor holding brake, feedback signal, brake open

Configuration, control/status words

- p1215 Holding brake configuration
- r1229 CO/BO: Motor holding brake status word
- p1275 Motor holding brake control word

Function diagram overview (refer to the List Manual)

- 2704 Zero speed detection (r0108.14 = 1)
- 2707 Releasing/applying brake (r0108.14 = 1)
- 2711 Signal outputs (r0108.14 = 1)

Control and status messages for extended brake control

Table 4-2 Control: extended brake control

Signal name	Binector input	Control word sequence control/ interconnection parameters
Enable speed setpoint	p1142 BI: Enable speed setpoint	STWA.6
Enable setpoint 2	p1152 BI: Setpoint 2 enable	p1152 = r899.15
Unconditionally release holding brake	p0855 BI: Unconditionally release holding brake	STWA.7
Enable speed controller	p0856 BI: Enable speed controller	STWA.12
Unconditionally close the holding brake	p0858 BI: Unconditionally close the holding brake	STWA.14

Table 4-3 Status message: extended brake control

Signal name	Parameter	Brake status word
Command, open brake (continuous signal)	r1229.1	B_ZSW.1
Pulse enable, expanded brake control	r1229.3	B_ZSW.3
Brake does not open	r1229.4	B_ZSW.4
Brake does not close	r1229.5	B_ZSW.5
Brake threshold exceeded	r1229.6	B_ZSW.6
Brake threshold fallen below	r1229.7	B_ZSW.7
Brake monitoring time expired	r1229.8	B_ZSW.8
Request, pulse enable missing/n_ctrl inhibited	r1229.9	B_ZSW.9
Brake OR logic operation result	r1229.10	B_ZSW.10
Brake AND logic operation result	r1229.11	B_ZSW.11

4.4.3 Description

The "Extended brake control" function allows complex braking control for motor holding brakes and operational brakes.

The brake is controlled as follows (the sequence reflects the priority):

- Via parameter p1215
- Via binectors p1219[0..3] and p0855
- Via zero speed detection
- Via a connector interconnection threshold value

4.4.4 Examples

Starting against applied brake

When the device is switched on, the setpoint is enabled immediately (if other enable signals are issued), even if the brake has not yet been released ($p1152 = 1$). The factory setting $p1152 = r0899.15$ must be disconnected here. The drive first generates torque against the applied brake. The brake is not released until the motor torque or motor current ($p1220$) has exceeded braking threshold 1 ($p1221$).

This configuration is used, for example, when the drive is connected to a belt that is under tension (loop accumulator in the steel industry).

Emergency brake

If emergency braking is required, electrical and mechanical braking is to take place simultaneously. This can be achieved if OFF3 is used as a tripping signal for emergency braking:

$p1219[0] = r0898.2$ (OFF3 to "apply brake immediately").

This is often used, for example, in calendar stacks, cutting tools, running gears, and presses.

Operating brake for crane drives

For cranes with a manual control, it is important that the drive immediately response when the control lever is moved (master switch). The drive is powered-up using the on command (p0840) (the pulses are enabled). Speed setpoint (p1142) and speed controller (p0856) are inhibited. The motor is magnetized. The magnetization time generally applicable for three-phase motors (1–2 seconds) is therefore eliminated.

Now, there is only the brake opening time that is applicable as delay between moving the master switch and the motor rotating. If the master switch is moved (deflected), then there is a "setpoint enable from the control" (bit interconnected with p1142, p1229.2, p1224.0). The speed controller is immediately enabled – the speed setpoint is enabled after the brake opening time (p1216). When the master switch is in the zero position, the speed setpoint is inhibited – the drive is ramp-down using the ramp-function generator. The brake closes once the standstill limit (p1226) has been fallen below. After the brake closing time (p1217), the speed controller is inhibited (the motor is now not generating any force!) The extended brake control is used with the modifications described below.

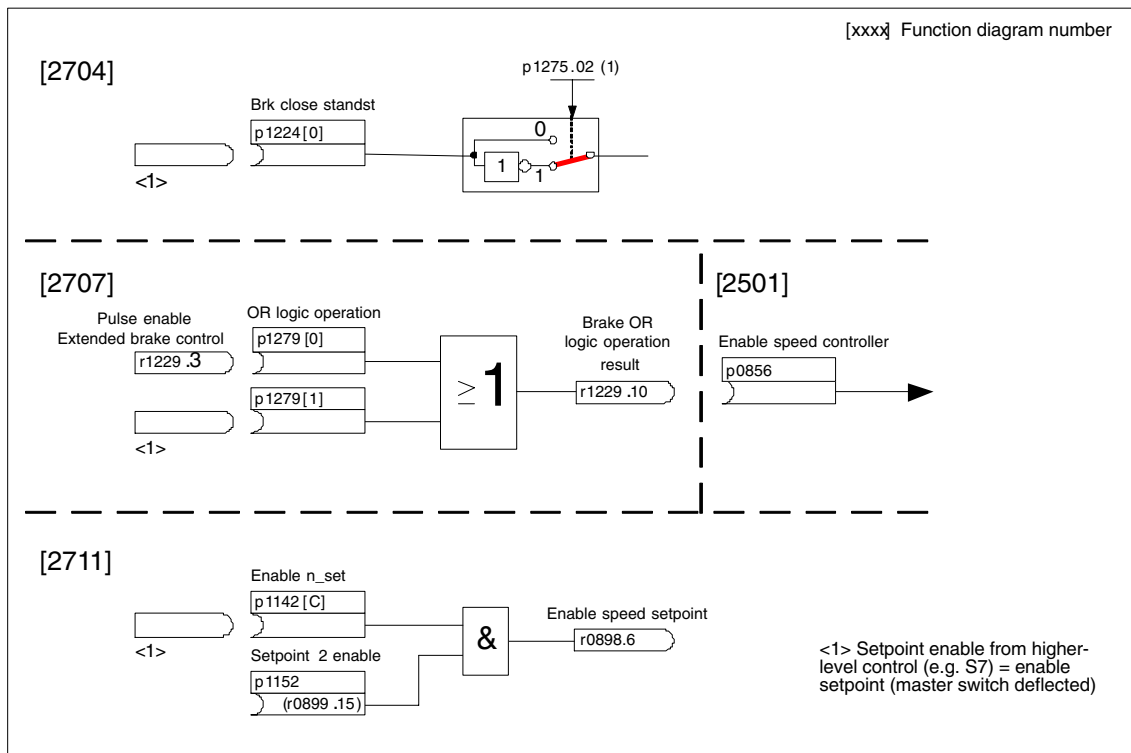


Fig. 4-5 Example, operating brake for a crane drive

4.4.5 Commissioning

The extended brake control function can be activated while the commissioning Wizard is running. Parameter r0108.14 indicates whether the function module has been activated.

Unless you change the default settings, the extended brake control function behaves in exactly the same way as the simple brake control function.

The brake control is activated automatically ($p1215 = 1$) if the Motor Module has an internal brake control function and a connected brake has been found.

If the component does not have an internal brake control function, control can be activated via parameter ($p1215 = 3$).

Caution

If $p1215 = 0$ (no brake available) is set when a brake is present, the drive runs with applied brake. This can destroy the brake.

4.5 Runtime (operating hours counter)

Total system runtime

The total system runtime is displayed in p2114 (Control Unit). Index 0 indicates the system runtime in milliseconds after reaching 86.400.000 ms (24 hours), the value is reset. Index 1 indicates the system runtime in days.

When the system is switched off, the counter value is saved.

When the drive unit is switched on, the counter continues to run with the value that was saved when the system was last switched off.

Relative system runtime

The relative system runtime after the last POWER ON is displayed in p0969 (Control Unit). The value is in milliseconds and the counter overflows after 49 days.

Actual motor operating hours

The motor operating hours counter p0650 (drive) is started when the pulses are enabled. When the pulse enable is withdrawn, the counter is stopped and the value saved.

The value can only be stored with a CU320 with Order No. 6SL3040-....-0AA1 and version C or higher.

If p0651 = 0, the counter is deactivated.

If the maintenance interval set in p0651 is reached, fault F01590 is triggered. Once the motor has been maintained, the maintenance interval must be reset.

Operating hours counter for the fan

The operating hours of the fan in the power section are displayed in p0251.

The number of hours operated can only be reset to 0 in this parameter (e.g. after the fan has been replaced). The service life of the fan is entered in p0252 (drive).

Alarm A30042 is output 500 hours before this figure is reached. Monitoring is deactivated when p0252 = 0.

4.6 Automatic restart (vector, infeed)

Description

The automatic restart function is used to automatically restart the drive/drive group when the line returns after a power failure. In this case, all of the faults present are automatically acknowledged and the drive is powered-up again. This function is not only restricted to line supply faults; it can also be used to automatically acknowledge faults and to restart the motor after any fault trips. In order to allow the drive to be powered-up while the motor shaft is still rotating, the “flying restart” function should be activated using p1200.

Note

An additional version of the automatic restart function is described in Section 4.20 (single-motor drive comprising the infeed and vector components).

Caution

Automatic restart functions in the vector operator mode and for infeeds with closed-loop infeed control. After the line supply voltage is connected, Smart Line Modules 5kW/10kW automatically power themselves up.



Warning

If p1210 is set to the value > 1, after the line supply returns, the Line Modules/ motors can automatically start. This is especially critical, if, after longer line supply failures, motors come to a standstill (zero speed) and it is incorrectly assumed that they have been powered-down. For this reason, entering the area around the drive when it is in this condition can cause death, serious injury, or considerable material damage.

Automatic restart mode

Table 4-4 Automatic restart mode

p1210	Mode	Meaning
0	Disable automatic restart mode	Automatic restart inactive
1	Acknowledges all faults without restarting	When p1210 = 1, faults that are present are acknowledged automatically when their cause is rectified. If further faults occur after faults have been acknowledged, then these are also again automatically acknowledged. A minimum time of p1212 + 1s must expire between successful fault acknowledgement and a fault re-occurring if the signal ON/OFF1 (control word 1, bit 0) is at a HIGH signal level. If the ON/OFF1 signal is at a LOW signal level, the time between a successful fault acknowledgement and a new fault must be at least 1s. For p1210 = 1, fault F07320 is not generated if the acknowledge attempt failed – for example because the faults occurred too frequently.
4	Automatic restart after line supply failure, no additional start attempts	For p1210 = 4, an automatic restart is only carried-out if in addition fault F30003 occurred at the Motor Module or there is a high signal at binector input p1208[1], or in the case of an infeed drive object (x_Infeed) F06200 has occurred. If additional faults are present, then these faults are also acknowledged and when successfully acknowledged, the starting attempt is continued. When the 24 V power supply of the CU fails, this is interrupted as a line supply failure.
6	Restart after any fault with additional start attempts	When p1210 = 6, an automatic restart is carried out after any fault or when p1208[0] = 1. If the faults occur one after the other, then the number of start attempts is defined using p1211. Monitoring over time can be set using p1213.

Starting attempts (p1211) and waiting time (p1212)

p1211 is used to specify the number of starting attempts. The number is internally decremented after each successful fault acknowledgement (line supply voltage must be re-applied or the infeed signals that it is ready. Fault F07320 is output if the number of parameterized start attempts has been reached.

When $1211 = x, x + 1$ starting attempts are made.

Note

A start attempt immediately starts when the fault occurs.

The faults are automatically acknowledged in intervals of half the waiting time p1212.

After successfully acknowledgment and the voltage returns, then the system is automatically powered-up again.

The start attempt has been successfully completed if the flying restart and the motor magnetization (induction motor) has been completed ($r0056.4 = 1$) and one additional second has expired. The starting counter is only reset back to the initial value p1211 after this time.

If additional faults occur between successful acknowledgement and the end of the starting attempt, then the starting counter, when it is acknowledged, is also decremented.

Monitoring time line supply return (p1213)

The monitoring time starts when the faults are detected. If the automatic acknowledgements are not successful, the monitoring time runs again. If the drive has not successfully started again after the monitoring time has expired (flying restart and motor magnetization must have been completed: $r0056.4 = 1$), fault F07320 is output. The monitoring is de-activated with $p1213 = 0$. If p1213 is set lower than the sum of p1212, the magnetization time r0346 and the additional delay time due to flying restart, then fault F07320 is generated at each restart. If, for $p1210 = 1$, the time in p1213 is set lower than p1212, then fault F07320 is also generated at every restart attempt. The monitoring time must be extended if the faults that occur cannot be immediately and successfully acknowledged (e.g. when faults are permanently present).

Commissioning

1. Activating the function for vector and infeed drive object
 - Automatic restart: set mode (p1210).
 - Flying restart: Activate function (p1200).
2. Set starting attempts (p1211).
3. Set waiting times (p1212, p1213).
4. Check function.

Important parameters (refer to the List Manual)

- r0863 CO/BO: Drive coupling status word/control word
- p1207 BI: Automatic restart – connection to the following DO
- p1208 BI: Automatic restart – infeed fault
- p1210 Automatic restart, mode
- p1211 Automatic restart, attempts to start
- p1212 Automatic restart, delay time start attempts
- p1213 Automatic restart, waiting time increment

4.7 Function module, parallel connection of chassis power units (vector)

4.7.1 Features

SINAMICS supports the parallel connection of power units on the motor and infeed side to extend the power spectrum of the SINAMICS.

The main characteristics of the parallel connection are:

- Parallel connection of up to four power sections on one motor
 - With parallel connection of several power units to one motor with separate winding systems (p7003 = 1)

Note:

We recommend motors with separate winding systems.

- Connecting several power units in parallel to a motor with a single winding system (p7003 = 0)



Caution

Additional information and instructions in the Equipment Manual must be carefully taken into consideration.

- Parallel connection of up to four power sections on the infeed side (closed/open loop)
- A CU320 can implement a maximum of one parallel connection on the mains connection and one parallel connection on the infeed side.
- Simple commissioning, because no special parameterization is necessary.
- The power sections connected in parallel must be connected to the same Control Unit.
- Individual power units can be diagnosed (troubleshooting) using p7000ff

4.7.2 Integration

Important parameters (refer to the List Manual)

- p0120 Power Module data set (PDS) number
- p0121 Power module component number
- p0602 Power module temperature sensor with parallel connection
- r7000 Parallel circuit configuration, number of active power modules
- r7001 Parallel circuit configuration, enable power modules
- r7002 Parallel circuit configuration, status power modules
- p7003 Parallel circuit configuration, winding system
- p7010 Parallel circuit configuration, current asymmetry alarm threshold
- p7011 Parallel circuit configuration, DC link voltage asymmetry alarm threshold
- ...
- p7322 Parallel circuit configuration, VSM line filter capacitance, phase W

4.7.3 Description

Switching power units in parallel is a simple method of extending the power spectrum of drives beyond the power of the individual power units.

4.7.4 Application examples

Parallel connection of two Motor Modules to one motor with double winding system

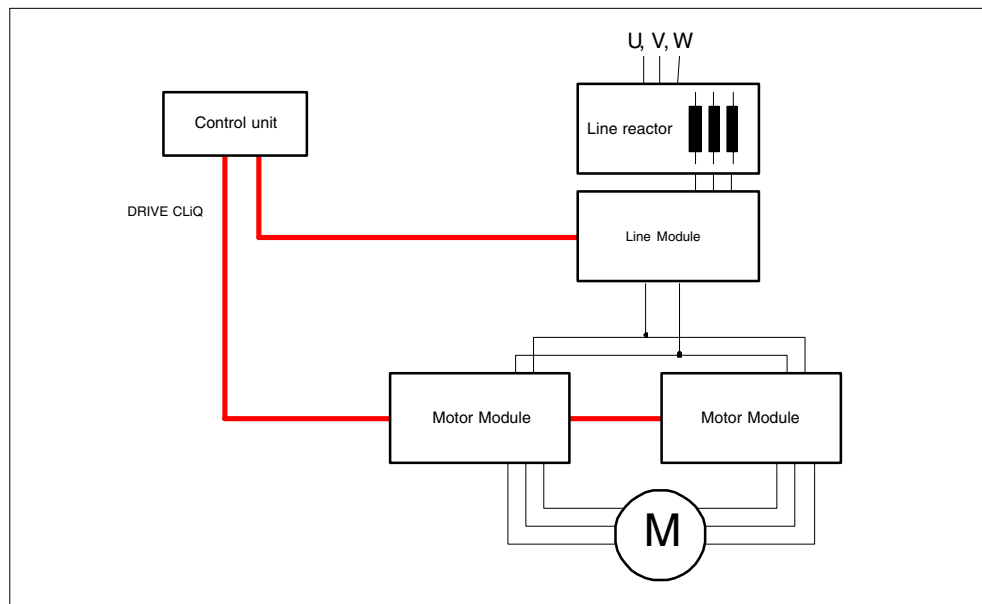


Fig. 4-6 Example 1: parallel connection

Parallel connection of two Active Line Modules and two Motor Modules on a motor with a single winding system

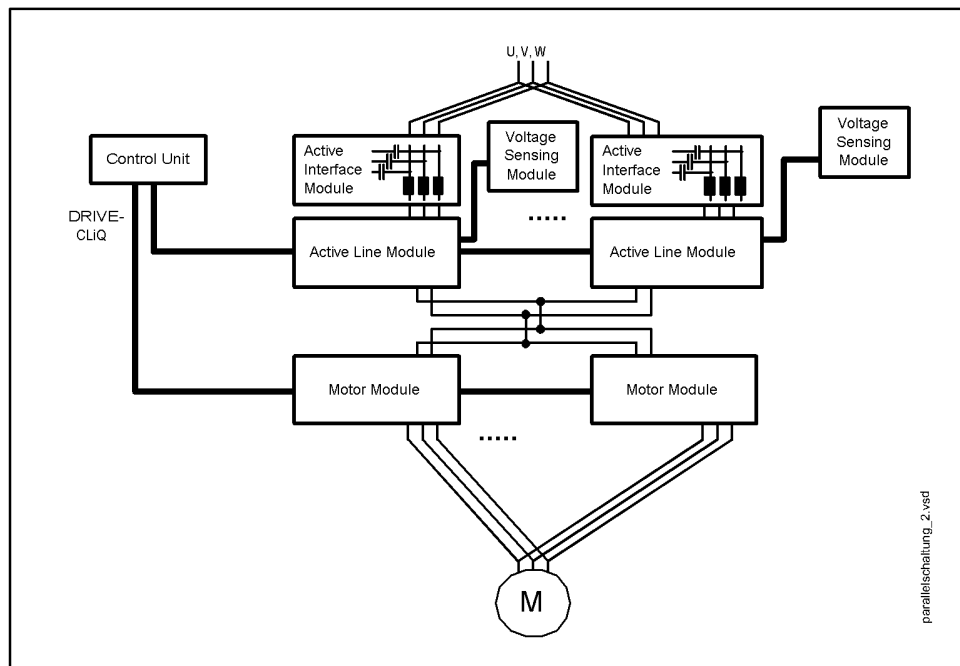


Fig. 4-7 Example 2: parallel connection

4.7.5 Commissioning

During commissioning, power sections connected in parallel are treated like a power section on the line or motor side. With parallel connection, the parameter display for the actual values changes only slightly. Instead, suitable “total values” are derived from the individual values for the power sections.

In STARTER, parallel connection (Line Modules and Motor Modules) is activated via the Wizard. You can also select parallel connection when choosing the power section. You then have to specify the number of power sections to be connected in parallel.

4.8 Redundant operation of the power units (vector)

Features

- Redundancy for power units
- Power unit can be de-activated via parameter (p0125)
- Power unit can be de-activated via binector input (p0895)

Description

Redundant operation can be used so that operation can be continued in spite of the failure of one power unit connected in parallel. In order that the failed power unit can be replaced, DRIVE-CLiQ cables must be connected in a star-type configuration – it may be necessary to use a DRIVE-CLiQ HUB Module (DMC20). The power unit can be de-activated using p0125 or using binector input p0895 (also refer to Section 4.12).

Conditions

- Minimum firmware release 2.4
- Connecting power units in parallel with the appropriate power reserves (also refer to Section 4.7).
- DRIVE-CLiQ star topology (possibly a DMC20, refer to the Equipment Manual)
- Motor with one single-winding system (p7003 = 0)
- No safe standstill

Integration

The boot function with partial topologies is integrated in the system as follows.

- p0125 Activate/de-activate power unit component
- r0126 Power unit component active/inactive
- p0895 BI: Activate/deactivate power unit component
- p7003 Par_circuit winding system

4.9 Technology function: friction characteristic

Description

The friction characteristic curve is used to compensate the friction torque for the motor and the driven machine. A friction characteristic enables the speed controller to be pre-controlled and improves the response.

10 interpolation points are used for each friction characteristic curve. The coordinates of an interpolation point are described by a speed (p382x) and a torque parameter (p383x) (interpolation point 1 = p3820 and p3830).

Features

- 10 interpolation points are available for mapping the friction characteristic curve.
- An automatic function allows you to record the friction characteristic curve (record friction characteristic curve).
- A connector output (r3841) can be applied as friction torque (p1569).
- The friction characteristic can be activated and deactivated (p3842).

Overview of important parameters (refer to the List Manual)

- p3820 Friction characteristic curve value n0
- ...
- p3839 Friction characteristic curve value M9
- r3840 CO/BO: friction characteristic curve status
- r3841 CO: friction characteristic curve output
- p3842 Friction characteristic curve activation
- p3845 Friction characteristic curve record activation

Function diagrams (refer to the List Manual)

- 5610 Torque limitation/reduction/interpolator
- 6710 Current setpoint filter
- 7010 Friction characteristic

Commissioning via parameters

In p382x, speeds for the measurement are predefined as a function of the maximum speed p1082 during initial commissioning. They can be changed appropriately.

p3845 can be used to activate the automatic friction characteristic curve recording. The characteristic curve is recorded the next time a pulse is enabled.

The following settings are possible:

- p3845 = 0 Friction characteristic curve recording deactivated
- p3845 = 1 Friction characteristic curve recording activated, all directions of rotation

The friction characteristic curve is recorded in both directions of rotation. The result of the positive and negative measurement is determined and entered in p383x.

- p3845 = 2 Friction characteristic curve recording activated, positive direction of rotation
- p3845 = 3 Friction characteristic curve recording activated, negative direction of rotation



Danger

When the friction curve is being recorded, the drive triggers movements in the motor that can reach the maximum motor speed.

The emergency OFF functions must be fully operational during commissioning. To protect the machines and personnel, the relevant safety regulations must be observed.

Commissioning via STARTER

In STARTER, the friction characteristic curve can be commissioned via the screen under "Functions".

4.10 Motor changeover

4.10.1 Description

The motor changeover is used in the following cases, for example:

- Changing-over between different motors and encoders
- Switching over different windings in a motor (e.g. star-delta switchover)
- Adapting the motor data

If several motors are operated alternately on a Motor Module, a matching number of drive data sets must be created (also refer to Section 5.2).

Note

To switch to rotating motor, the “flying restart” function must be activated (p1200).

Notice

When changing over the drive data set between several motors that physically exist with integrated holding brakes, it is not permissible that the internal brake control is used.

4.10.2 Integration

The motor switchover function is integrated in the system as follows.

Function diagram overview (refer to the List Manual)

- 8565 Drive data set (DDS)
- 8570 Encoder data set (EDS)
- 8575 Motor data set (MDS)

Overview of important parameters (refer to the List Manual)

- r0051 Drive data set (DDS) effective
- p0130 Motor data set (MDS) number
- p0140 Encoder data set (EDS) number
- p0180 Drive data sets (DDS) number
- p0186 Motor data sets (MDS) number
- p0187 Encoder 1 encoder data
- p0820 BI: Drive data set selection DDS, bit 0
- ...
- p0824 BI: Drive data set selection DDS, bit 4
- p0826 Motor switchover motor number
- p0827 Motor switchover status bit number
- p0828 BI: Motor switchover feedback
- p0830 CO/BO: Motor switchover status
- p0831 BI: Motor switchover contactor feedback
- p0833 Data set changeover configuration

4.10.3 Example: motor switchover for four motors

Prerequisites:

- Initial commissioning is complete.
- 4 motor data sets (MDS), p0130 = 4
- 4 drive data sets (DDS), p0180 = 4
- 4 digital outputs for controlling the auxiliary contactor
- 4 digital inputs for monitoring the auxiliary contactor
- 2 digital inputs for selecting the data set
- 4 auxiliary contactors with auxiliary contacts (1 NO contact)
- 4 motor contactors with positively-driven auxiliary contacts (3 NC contacts, 1 NO contact)
- 4 motors, 1 Control Unit, 1 infeed, and 1 Motor Module

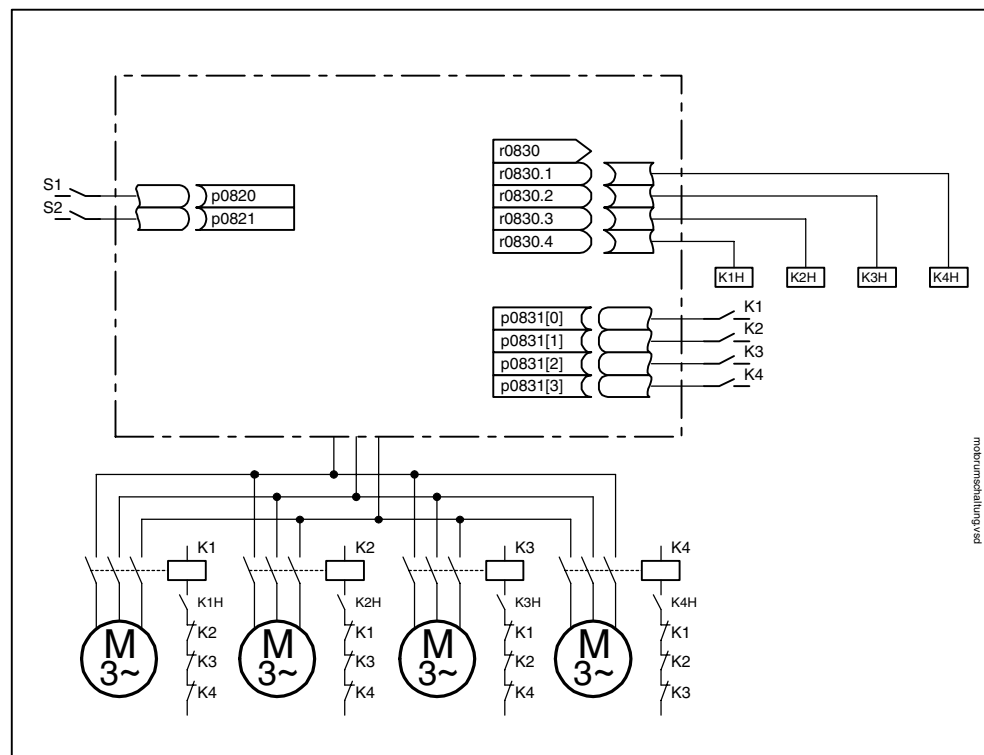


Fig. 4-8 Example: motor switchover

Table 4-5 Settings for the example

Parameter	Settings	Comments
p0130	4	Configure 4 MDS.
p0180	4	Configure 4 DDS.
p0186[0..3]	0, 1, 2, 3	The MDS are assigned to the DDS.
p0820, p0821	Digital inputs DDS selection	The digital inputs for motor switchover via DDS selection are selected. The coding is binary (p0820 = bit0 etc.).
p0822 to p0824	0	
p0826[0..3]	1, 2, 3, 4	Different numbers indicate a different thermal model
p0827[0..3]	1, 2, 3, 4	Assign the bit from p0830 to the MDS. If p0827[0] = 1, for example, bit p0830.1 is set when MDS0 is selected via DDS0.
p0830.1 to p0830.4	Digital outputs auxiliary contactors	The digital outputs for the auxiliary contactors are assigned to the bits.
p0831[0..3]	Digital inputs auxiliary contacts	The digital inputs for the checkback from the motor contactors are assigned.
p0833.0..3	0, 0, 0	The drive is responsible for controlling the contactor circuit and the pulse inhibit. Parking bit (Gn_ZSW14) is set

Procedure for switching over the motor data set

1. Start condition:
With synchronous motors, the actual speed must be lower than the speed used in the field-weakening range. This ensures that the regenerative voltage generated is greater than the terminal voltage.
2. Pulse inhibit:
A pulse inhibit is activated once a new drive data set has been selected by means of p0820 to p0824.
3. Open motor contactor:
Motor contactor 1 is opened r0830 = 0 and the status bit "Motor switchover active" (r0835.0) is set.
4. Switch over drive data set:
The requested data set is activated (r0051 = requested data set).
5. Motor contactor activation:
After confirmation (motor contactor opened) from motor contactor 1, the corresponding bit in r0830 is set and motor contactor 2 is activated.
6. Enable pulses:
After confirmation (motor contactor closed) from motor contactor 2, the bit "Motor switchover active" (r0835.0) is reset and the pulses are enabled again. The motor switchover is complete.

4.10.4 Example of a star/delta switchover

Prerequisites:

- Initial commissioning is complete.
- 2 motor data sets (MDS), p0130 = 2
- 2 drive data sets (DDS), p0180 = 2
- 2 digital outputs for controlling the auxiliary contactor
- 2 digital inputs for monitoring the auxiliary contactor
- 1 free speed monitoring (p2155)
- 2 auxiliary contactors with auxiliary contacts (1 NO contact)
- 2 motor contactors with positively-driven auxiliary contacts (1 NC contacts, 1 NO contact)
- 1 motor, 1 Control Unit, 1 infeed, and 1 Motor Module

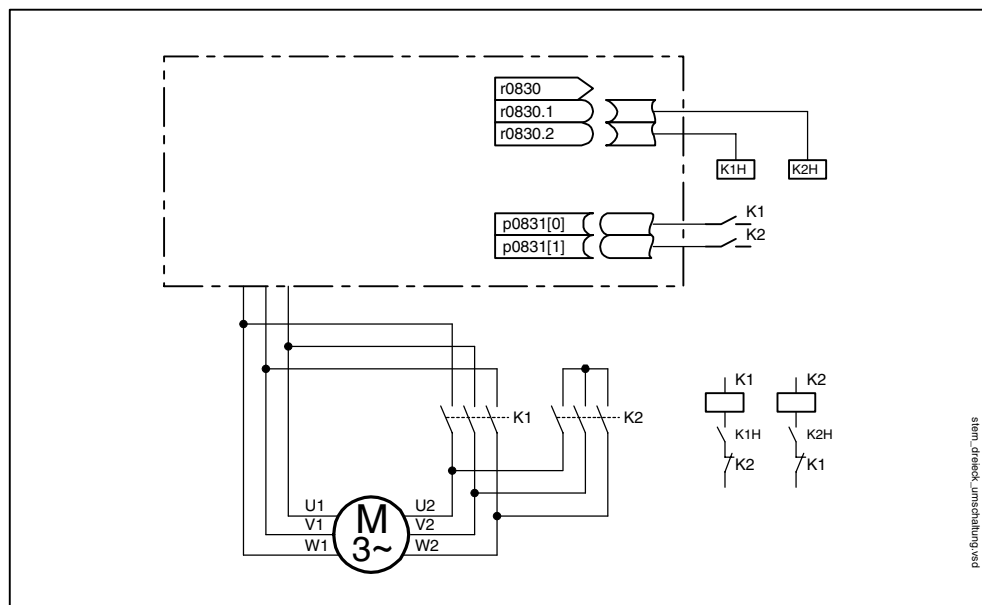


Fig. 4-9 Example: star/delta switchover

Table 4-6 Settings for the example

Parameter	Settings	Comments
p0130	2	Configure 2 MDS.
p0180	2	Configure 2 DDS.
p0186[0..1]	0, 1	The MDS are assigned to the DDS.
p0820	p2197.2	Switchover to delta connection after speed in p2155 is exceeded.
p0821 to p0824	0	
p0826[0..1]	0; 0	Identical numbers signify the same thermal model.
p0827[0..1]	1, 2	Assign the bit from p0830 to the MDS. If p0827[0] = 1, for example, bit p0830.1 is set when MDS0 is selected via DDS0.
p0830.1 and p0830.2	Digital outputs auxiliary contactors	The digital outputs for the auxiliary contactors are assigned to the bits.
p0831[0..1]	Digital inputs auxiliary contacts	The digital inputs for the checkback from the motor contactors are assigned.
p0833[0..1]	0, 0, 0	The drive is responsible for controlling the contactor circuit and the pulse inhibit. Parking bit (Gn_ZSW14) is set
p2155	Switchover speed	Sets the speed at which the switchover is to be carried out in delta.

Procedure for star/delta switchover

1. Start condition:
With synchronous motors, the actual speed must be lower than the speed used in the field-weakening range. This ensures that the regenerative voltage generated is greater than the terminal voltage.
2. Pulse inhibit:
A pulse inhibit is activated once a new drive data set has been selected by means of p0820.
3. Open motor contactor:
Motor contactor 1 is opened r0830 = 0 and the status bit "Motor data set switchover aktiv" (r0835.0) is set.
4. Switch over drive data set:
The requested data set is activated (r0051 = requested data set).
5. Motor contactor activation:
After confirmation (motor contactor opened) from motor contactor 1, the corresponding bit in r0830 is set and motor contactor 2 is activated.
6. Enable pulses:
After confirmation (motor contactor closed) from motor contactor 2, the bit "Motor switchover active" (r0835.0) is reset and the pulses are enabled again. The switchover is complete.

4.11 Simulation mode (vector)

4.11.1 Description

Simulation mode allows you to simulate the drive without a connected motor and without the DC link voltage. When doing so, note that simulation mode can only be activated with an actual DC link voltage of 40 V. If the voltage is higher, simulation mode is reset and fault message F07826 is output.

Simulation mode enables you to test communication with a higher-level automation system. If the drive is also to return actual values, note that it must be switched over to sensorless operation (V/f) during simulation mode. A range of components in the SINAMICS software (e.g. setpoint channel, sequence control, communication, technology function, etc.) must be tested in this way beforehand.

Simulation mode also allows you to test the power section. Particularly with devices greater than 75 kW (690 V) and 110 kW (400 V), you must check that the power semi-conductor can be activated properly after repairs. To do so, apply a small direct current as the DC link voltage (e.g. 12 V), switch on the device, and enable the pulses. It must be possible to pass through all the pulse patterns of the gating unit software.

The software must, therefore, allow the pulses to be activated and the system to approach different frequencies. If a speed encoder is not installed, this is usually carried out by means of V/f control or sensorless speed control.

Note

Simulation mode cannot be activated without a power section. A power section must be connected via DRIVE-CLiQ.

4.11.2 Features

- Automatic deactivation with a DC link voltage greater than 40 V (measurement tolerance ± 16 V) with fault message F07826 and immediate pulse inhibit (OFF2)
- Can be activated via parameter p1272
- Deactivation of line contactor activation during simulation mode
- Activation of power semi-conductor with low DC link voltage and with motor (for test purposes).
- The power section and control can be simulated without a connected motor.

4.11.3 Commissioning

Simulation mode can be activated via p1272 =1. The following prerequisites must be fulfilled:

- Initial commissioning must be complete (default: standard induction motors).
- The DC link voltage must be below 40 V (note tolerance of DC link sensor).

4.12 Parking axis and parking sensor

4.12.1 Description

The parking function is used in two ways:

- “Parking sensor”
 - Monitoring of a certain encoder is suppressed.
 - The encoder is prepared for the “removed” state.
- “Parking axis”
 - Monitoring of all encoders and Motor Modules assigned to the “Motor control” application of a drive are suppressed.
 - All encoders assigned to the “Motor control” application of a drive are prepared for the “removed” state.
 - The Motor Module that is assigned the application “Motor control” of drive is prepared for the state “removed Motor Module”.

Parking a sensor

When a sensor is parked, the sensor being addressed is switched to inactive ($r0146 = 0$).

- Control is carried out via the sensor control/status words of the cyclic telegram (Gn_STW.14 and Gn_ZSW.14).
- With a parked motor measuring system, the associated drive must be brought to a standstill by the higher-level control system (disable pulses e.g. via STW1.0/OFF1).
- The monitoring functions for the power section remain active ($r0126 = 1$).

Parking an axis

When an axis is parked, the power section and all the sensors assigned to the “motor control” are switched to inactive ($r0146[n] = 0$).

- Control is carried out via the control/status words of the cyclic telegram (STW2.7 and ZSW2.7) or using parameters p0897 and r0896.0.
- The drive must be brought to a standstill by the higher-level controller (disable pulses e.g. via STW1.0/OFF1).
- DRIVE-CLiQ communication to downstream components via the deactivated power section ($r0126 = 0$) remains active.
- A measuring system that is not assigned to the “motor control” (e.g. direct measuring system) remains active ($r0146[n] = 1$).
- The drive object remains active ($r0106 = 1$).

Note

Once the “Parking axis” / “Parking sensor” status has been canceled, you may have to carry out the following actions:

If the motor encoder has been replaced: determine the commutation angle offset (p1990).

A new encoder must be referenced again (e.g. to determine the machine zero point).

4.12.2 Example: parking axis and parking sensor

Example: parking axis

In the following example, an axis is parked. To ensure that the axis parking is effective, the drive must be brought to a standstill (e.g. via STW1.0 (OFF1)). All components assigned to the motor control (e.g. power section and motor encoder) are shut down.

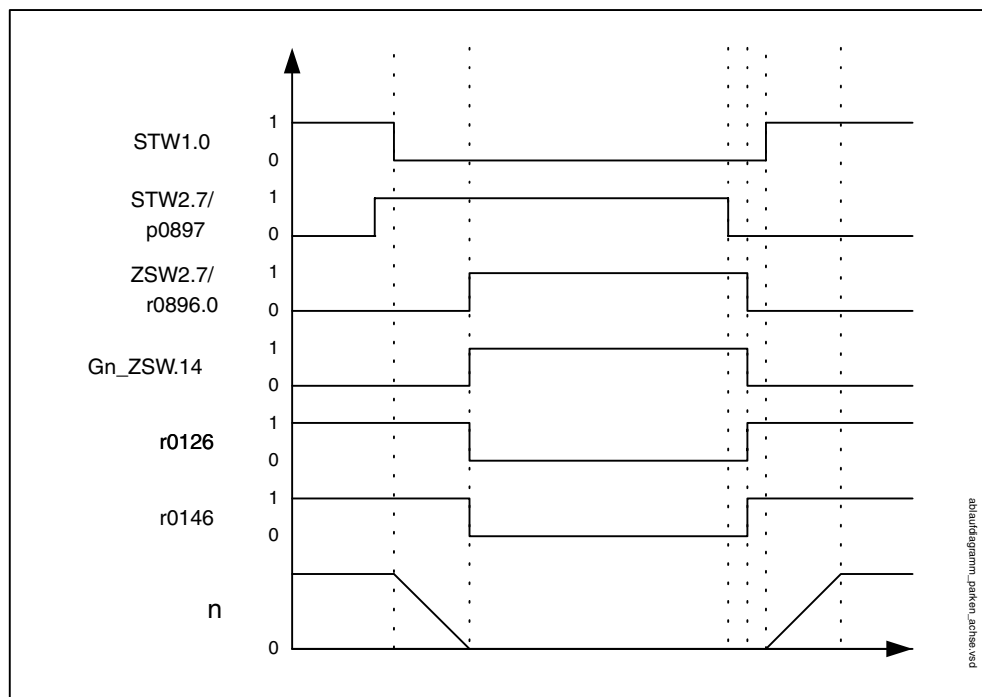


Fig. 4-10 Function chart: parking axis

Example: parking sensor

In the following example, a motor sensor is parked. To ensure that the motor sensor parking is effective, the drive must be brought to a standstill (e.g. via STW1.0 (OFF1)).

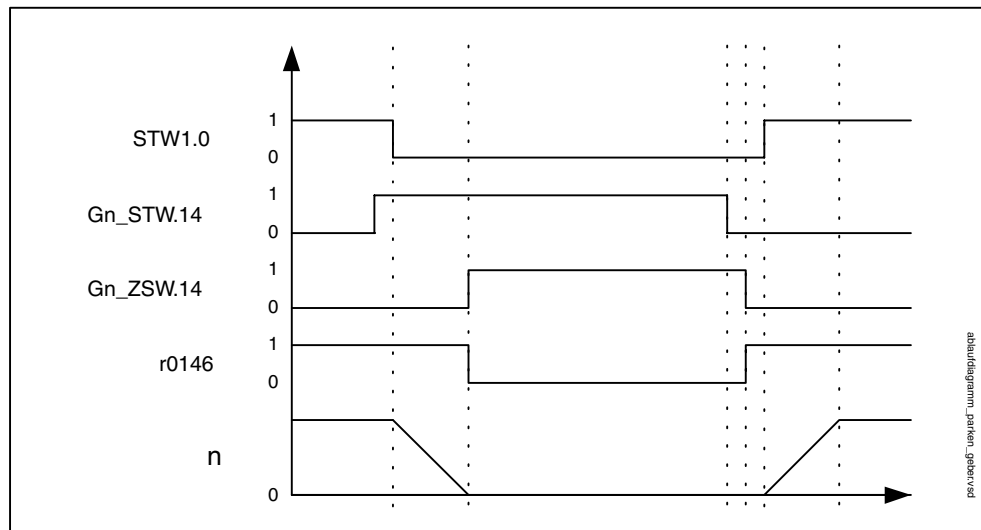


Fig. 4-11 Function chart: parking sensor

4.12.3 Overview of important parameters (refer to the List Manual)

- p0105 Activate/deactivate drive object
- r0106 Drive object active/inactive
- p0125 Activate power section component
- r0126 Power section component active
- p0145 Activate/deactivate encoder interface
- r0146 Encoder interface active/inactive
- r0896.0 Parking axis active
- p0895 BI: Activate/deactivate power unit component
- p0897 BI: Parking axis selection

4.13 Boot with partial topologies

4.13.1 Description

Booting of partial topologies is used:

- The monitoring of all encoders that are assigned a drive object (DO) is suppressed.
- All of the components that are assigned a drive object are prepared for the state “removed component”.

Example of booting partial topologies

The starting point is a unit where commissioning has been completed with a complete actual topology.

- A drive object “drive 1” must be replaced
- Spare parts are not available. Must be ordered
- The drive object “infeed 1” has BiCo connections as a signal drive to “drive 1”
- The remain drive objects must continue to operate
- After POWER OFF: DO3 is removed and the wiring adapted

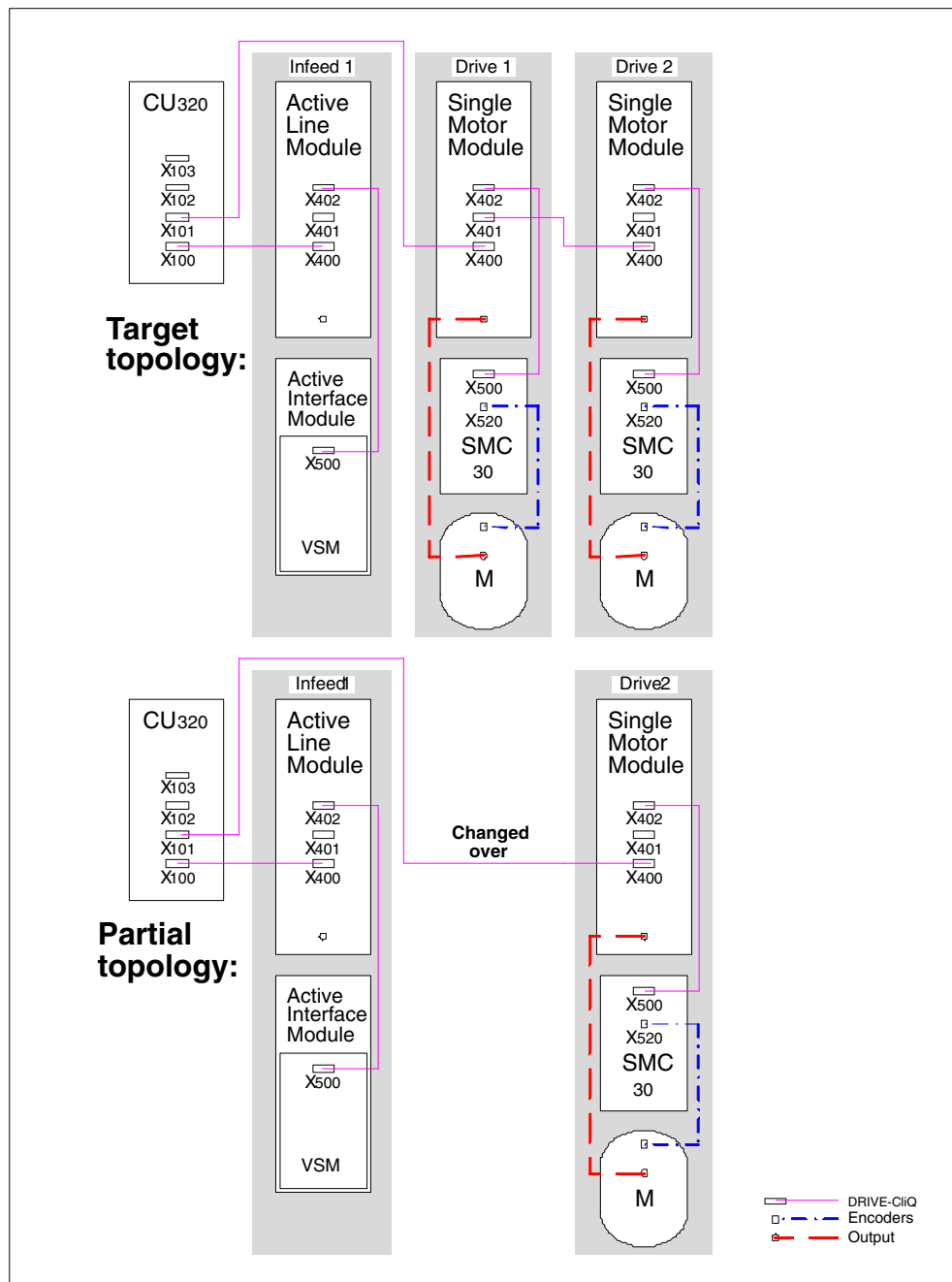


Fig. 4-12 Booting with partial topologies

Sequence after POWER ON with partial topology

- “Drive 1” is designated as “not capable of operation”
- Message A01315 for “Drive 1” is issued:
“Drive object not capable of operation: Activated components missing”
- Message A01507 for “Infeed 1” is output:
“BiCo: Connections to objects that are either not capable of operation or are inactive”
- Note the open BiCo connections:
p9495 (“Infeed 1”) = 1 (A01507 is reset)
- De-activate DO3: p0105 (“Drive 1”) = 0 (A01315 is reset)
- Using STARTER “Copy RAM to ROM” must be carried-out.
- It is not permissible to carry-out again “Load to drive unit”.

Spare part for “Drive 1” is available and after POWER OFF is installed and wired, sequence after POWER ON:

- The new serial number of “Drive 1” is copied into the target topology
- Message A01316 for “Drive 1” is issued:
“Drive object inactive and operational again”
- Message A01318 for “Infeed 1” is issued:
2BiCo: Open connections exist”
- Activate “Drive 1”: p0105 (“Drive 1”) = 1 (A01316 is reset)
- Establish the old BICO connections:
p9496 (“Infeed 1”) = 1 (A01318 is deleted)
- Using STARTER “Copy RAM to ROM” must be carried-out.
- “Load to drive unit” can be carried-out again.

Overview of important parameters (refer to the List Manual)

- p0105 Activate/deactivate drive object
- r0106 Drive object active/inactive
- p0125 Activate/de-activate power unit component
- r0126 Power unit component active/inactive
- p0145 Activate/deactivate encoder interface
- r0146 Encoder interface active/inactive
- p9495 BICO response to de-activated drive objects
- p9496 Re-establish BICO to the now activated drive objects
- r9498[0 ... 29] BICO BI/CI parameter to de-activated drive objects
- r9499[0 ... 29] BICO BO/CO parameter to de-activated drive objects

4.14 Sinusoidal filter

Description

The sinusoidal filter limits the rate of rise of voltage and the capacitive charge/discharge currents that usually occur with inverter operation. They also prevent additional noise caused by the pulse frequency. The service life of the motor is the same as that with direct line operation.

Caution

If a sinusoidal filter is connected to the converter, the converter must be activated during commissioning to prevent the filter from being destroyed.

Usage restrictions for sinusoidal filters

The following restrictions must be taken into account when a sinusoidal filter is used:

- The output frequency is limited to a maximum of 150 Hz.
- The modulation type is permanently set to space vector modulation without overmodulation. This reduces the maximum output voltage to approx. 85 % of the rated output voltage.
- Maximum permissible motor cable lengths:
 - Unshielded cables: max. 150 m
 - Shielded cables: max. 100 m
- Other restrictions: see the Equipment Manual.

Note

If a filter cannot be parameterized (p0230 not 3), this means that a filter has not been provided for the component. In this case, the drive converter must not be operated with a sinusoidal filter.

Table 4-7 Parameter settings for sinusoidal filters

Order No.	Name	Setting
p0233	Power module motor reactor	Filter inductance
p0234	Power module sinusoidal filter capacitance	Filter capacitance
p0290	Power module overload response	Disable pulse frequency reduction
p1082	Maximum rotational speed	Fmax filter/pole pair number
p1800	Pulse frequency	Nominal pulse frequency of the filter
p1802	Modulator modes	Space vector modulation without overmodulation

4.15 dv/dt filter plus VPL

Description

The dv/dt filter plus VPL comprises two components, the dv/dt reactor and the voltage limiting line voltage value (**V**oltage **P**eak **L**imiter), which removes the voltage peaks and feeds the energy back into the DC link.

The dv/dt filter plus VPL is to be used for motors for which the voltage strength of the insulation system is unknown or insufficient. Standard motors of the 1LA5, 1LA6 and 1LA8 series only require them at supply voltages > 500 V +10 %.

The dv/dt filter plus VPL limits the rate of voltage rise to values < 500 V/ μ s and the typical voltage peaks to the values below (with motor cable lengths < 150 m):

< 1000 V at $V_{\text{line}} < 575$ V

< 1250 V at 660 V < $V_{\text{line}} < 690$ V.



Warning

When using a dv/dt filter, the maximum pulse frequency of the drive converter is 2.5 kHz or 4 kHz. If a higher pulse frequency is set, then this could destroy the dv/dt filter.

Restrictions

The following restrictions must be taken into account when a dv/dt filter is used:

- The output frequency is limited to a maximum of 150 Hz.
- Maximum permissible motor cable lengths:
 - Shielded cables: max. 300 m
 - Unshielded cables: max. 450 m
- Other restrictions: see the Equipment Manual.

Commissioning

The dv/dt filter must be activated when commissioning the system (p0230 = 2).

4.16 Flying restart (vector)

Description

After power ON, the “flying restart” function switches automatically to a Motor Module that may be coasting.

The “Flying restart” function should be activated via p1200 for an overrunning load. This prevents sudden loads in the entire mechanics.

With an induction motor, the system waits for a demagnetization time to elapse before the search is carried out. An internal demagnetization time is calculated. A time can also be entered in p0347. The system waits for the longer of the two times to elapse.

In operation without an encoder, a search is carried out initially for the current speed. A Voltage Sensing Module (VSM) is required for permanent-magnet synchronous motors for additional information, refer to the Equipment Manual.

For an induction motor, immediately after the speed has been determined, magnetization starts (p0346).

The current speed setpoint in the ramp-function generator is then set to the current actual speed value.

The ramp-up to the final speed setpoint starts with this value.

Application example: After a power failure, a fan drive can be quickly reconnected to the running fan motor by means of the flying restart function.

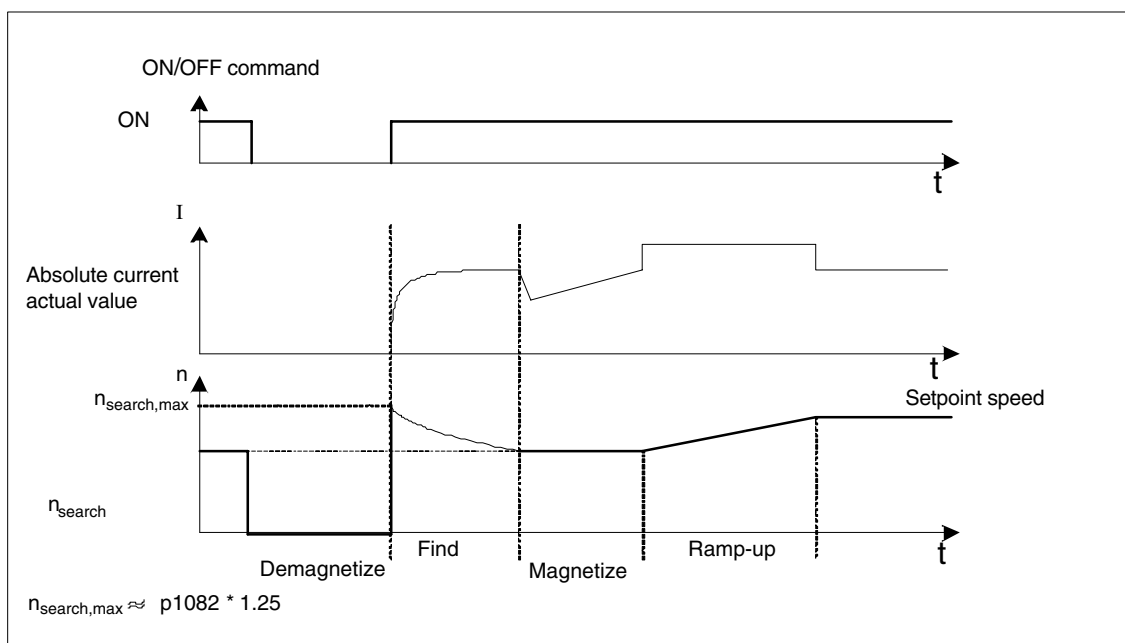


Fig. 4-13 Flying restart



Warning

When the flying restart (p1200) function is active, the drive may still be accelerated by the detection current despite the fact that it is at standstill and the setpoint is 0.

For this reason, entering the area around the drive when it is in this condition can cause death, serious injury, or considerable material damage.

Note

With induction motors, the demagnetization time must elapse before the flying restart function is activated to allow the voltage at the motor terminals to decrease otherwise high equalizing currents can occur when the pulses are enabled due to a phase short-circuit.

Overview of important parameters (refer to the List Manual)

- p1082 Maximum speed
- p1200 Flying restart operating mode
 - 0: Flying restart inactive
 - 1: Flying restart is always active (start in the setpoint direction).
 - 2: Flying restart is active after: power-on, fault, OFF2 (start in the setpoint direction).
 - 3: Flying restart is active after: fault, OFF2. (start in the setpoint direction).
 - 4: Flying restart is always active Start in setpoint direction **only**.
 - 5: Flying restart is active after: power-on, fault, OFF2 Start in setpoint direction **only**.
 - 6: Flying restart is active after: fault, OFF2, start in setpoint direction **only**.
- p1202 Flying restart search current
- p1203 Flying restart search rate factor
- r1204 CO/BO: Flying restart, V/f control status
- r1205 CO/BO: Flying restart, vector control status

4.17 Direction reversal without changing the setpoint

Features

- Not change to the speed setpoint and actual value, the torque setpoint and actual value and the relative position change.
- Only possible when the pulses are inhibited

Caution

If direction reversal is configured in the data set configurations (e.g. p1821[0] = 0 and p1821[1] = 1), then when the function module basic positioner or position control is activated, the absolute adjustment is reset each time the system boots or when the direction changes (p2507), as the position reference is lost when the direction reverses.

Description

The direction of rotation of the motor can be reversed using the direction reversal via p1821 without having to change the motor rotating field by interchanging two phases at the motor and having to invert the encoder signals using p0410.

The direction reversal via p1821 can be detected as a result of the motor direction of rotation. The speed setpoint and actual value, torque setpoint and actual value and also the relative position change remain unchanged.

The direction change can be identified as a result of the phase voltage (r0089). When the direction reverses, then the absolute position reference is also lost.

In the vector control mode, in addition, the output direction of rotation of the drive converter can be reversed using p1820. This means that the rotating field can be changed without having to interchange the power connections. If an encoder is being used, the direction of rotation must, when required, be adapted using p0410.

Overview: key parameters

- r0069 Phase current, actual value
- r0089 Actual phase voltage
- p1820 Direction of rotation reversal of the output phases (vector)
- p1821 Reversal of direction
- p2507 LR absolute encoder adjustment status

4.18 Armature short-circuit brake, internal voltage protection

Features

- For permanent magnet synchronous motors
 - Controlling an external armature short-circuit configuration
 - Internal voltage protection (booksize)
- Configuration via parameter (p1231)
- Status message using a parameter (r1239)

Description

The armature short-circuit and voltage protection functions cannot be simultaneously activated.

Armature short-circuit braking is only available for synchronous motors. They are mainly required when braking in a hazardous situation, if controlled braking using the drive converter is no longer possible, e.g. when the power fails, EMERGENCY STOP etc. or if a non-regenerative feedback infeed is used. In this case, the motor stator windings are short-circuited – either internally or via external braking resistors. This means that an additional resistance is inserted in the motor circuit that supports reducing the kinetic energy of the motor. In order that the drive remains in closed-loop control during voltage dips and failures, a buffered 24 V power supply (UPS) must be used. High-speed permanent-magnet spindle drives for machine tools are a typical application for armature short-circuit braking.

The functions can be initiated with a “0” signal at binector input p1230. Initially, the pulses are cancelled and then the armature is short-circuited or the voltage protection. Using r0046.4, the initiation of these functions via p1230 can be checked.

External armature short-circuit braking

This function controls an external contactor via output terminals that then short-circuits the motor through resistors. Armature short-circuit braking has the advantage with respect to a mechanical brake that at the start of braking (at a high speed), the braking effect is initially high. However, at lower speeds, the braking effect is significantly decreases – this is the reason that we recommend a combination with a mechanical brake.

The external armature short-circuit is activated via p1231 = 2 (with contactor feedback signal) or p1231 = 3 (without contactor feedback signal). It is initiated when the pulses are cancelled.

Prerequisites for activation are as follows:

- One of the following motor types was parameterized:
 - Rotating permanent-magnet synchronous motor
 - Linear permanent-magnet synchronous motor

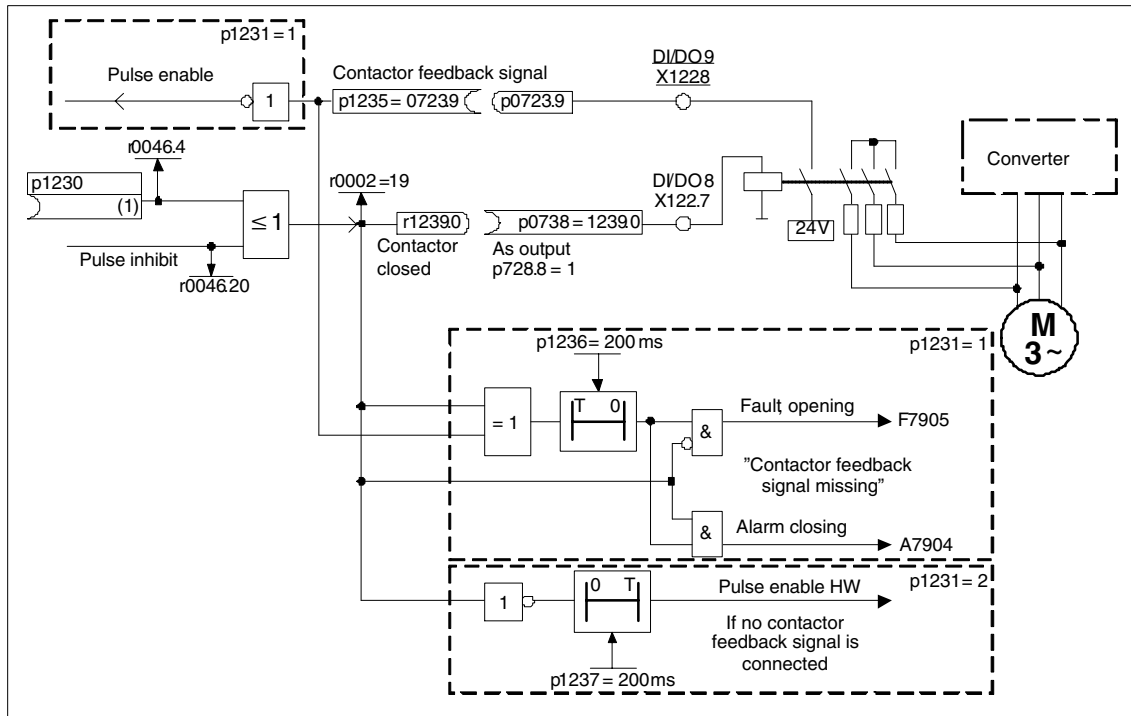


Fig. 4-14 Example of external armature short-circuit braking with/without contactor feedback signal

Internal voltage protection (booksize)

The internal voltage protection is used to protect the drive group when the pulses are cancelled. This is realized by short-circuiting a half bridge in the power unit.

The voltage protection is activated with $p1231 = 3$. It is initiated when the pulses are cancelled.

Prerequisites for activation are as follows:

- A Motor Module booksize is being used
- The power unit current ($r0289$) must be 180 % of the motor current ($p0331$).
- One of the following motor types was parameterized:
 - Rotating permanent-magnet synchronous motor
 - Linear permanent-magnet synchronous motor

Caution

When the internal voltage protection is active (p1231 = 3), after the pulses have been cancelled, all of the motor terminals are at half of the DC link potential (without internal voltage protection the motor terminals have a no voltage condition)!



Danger

The voltage protection is not switched-out. Kinetic energy is converted into heat (power loss) in the drive converter and motor. If the power loss is too high or if this operation takes too long, then this can result in thermal overload of the drive.

Function diagram overview (refer to the List Manual)

- 7014 External armature short-circuit (EASC, p0300 = 2)
- 7015 Internal voltage protection (IVP, p0300 = 2)

Overview of important parameters (refer to the List Manual)

- p1230 BI: Armature short-circuit activation
- p1231 Armature short-circuit configuration
- p1235 BI: Armature short-circuit, external contactor feedback signal
- p1236 Armature short-circuit, external contactor feedback signal monitoring time
- p1237 Armature short-circuit, external delay time when opening
- r1238 Armature short-circuit, external status
- r1239 CO/BO: Armature short-circuit, status word

4.19 OFF3 torque limits

Description

If the torque limits are externally specified (e.g. tension controller), then the drive can only be stopped with a reduced torque. If stopping in the selected time p3490 of the infeed has not been completed, the infeed shuts down and the drive coasts down.

In order to avoid this, there is a binector input (p1551), that for a LOW signal, activates the torque limits p1520 and p1521. This means that the drive can brake with the maximum torque by interconnecting the signal OFF 3 (r0899.5) to this binector.

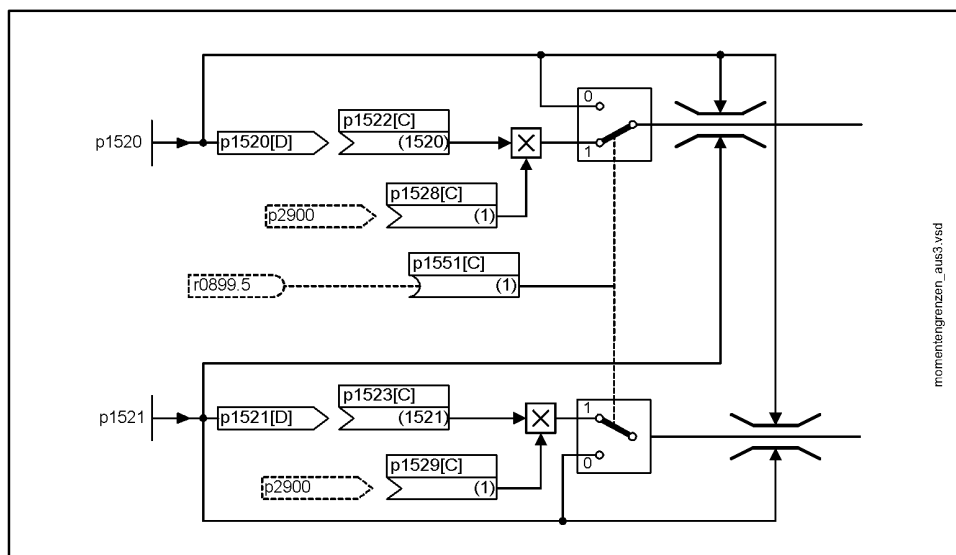


Fig. 4-15 Torque limits OFF3

Function diagram overview (refer to the List Manual)

- 5620 Torque limits, motoring/regenerating
- 6620 Upper/lower torque limit

Overview of important parameters (refer to the List Manual)

- p1520 Torque limit, upper/motoring
- p1521 Torque limit, lower/regenerating

4.20 Switching-in a drive object x_Infeed using a vector drive object

Description

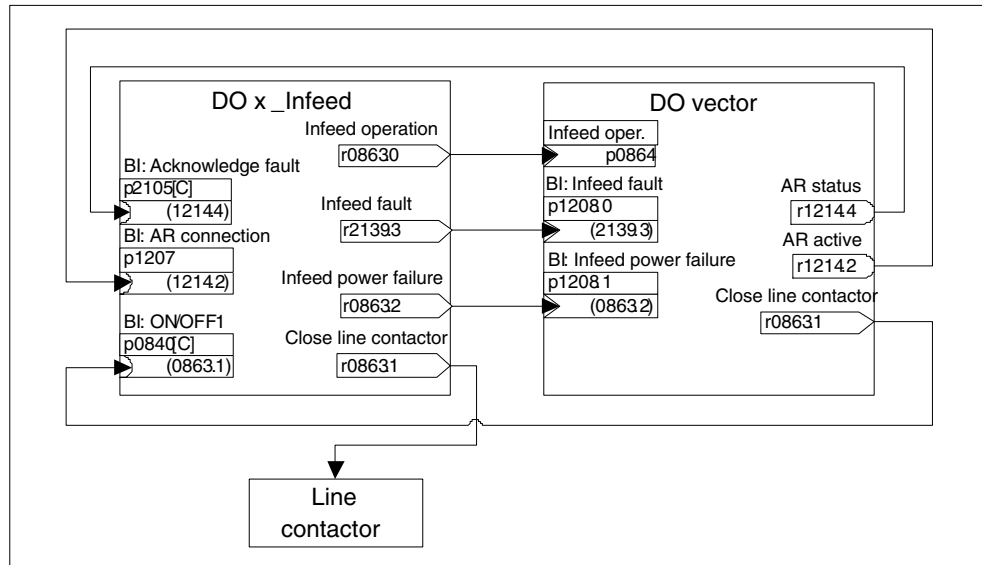


Fig. 4-16 BICO interconnection

Using this BICO interconnection, a drive object (DO) x_Infeed can be switched-in by a vector drive object. This power-on version is mainly used for chassis units, if only a line module and one Motor Module are used. If the associated application requires an automatic restart function then the following procedure is recommended in order to implement it:

- The automatic restart function is activated on the DO vector (p1210).
- In addition to the automatic restart function, the flying restart function (p1200) must be activated on DO vector if it must be assumed that an automatic restart must be made for a motor that is still rotating.

Individual steps when restarting:

- After the line supply returns and the electronics has booted, the faults that have occurred at DO vector as a result of its automatic restart are acknowledged depending on the settings in p1210.
- The faults of the DO x_Infeed are acknowledged via the connection r1214.4 => p2105.
- The ON command (p0840) for the infeed is generated via the binector output “control line contactor” of the DO vector (p0863.1).
- The power-on attempt is interrupted if, during the new power-on sequence, a fault occurs on the DO x_Infeed. The fault is communicated to the DO vector via the BiCo connection p1208.0 => r2139.3 shown above.
- The automatic restart of the DOs x_Infeed have absolutely no significance for the described power-on version.

4.21 "Braking Module" function module

Features

- Braking the motor without any possibility of regenerating into the line supply (e.g. power failure)
- Fast DC link discharge (booksize design)
- The braking module terminals are controlled via the drive object infeed (booksize and chassis designs)
- Controlling up to 8 Braking Modules in a parallel circuit configuration
- Acknowledging faults at the Braking Module

Description

The "Braking Module" function module can be activated in the infeed drive object. The appropriate binectors must be interconnected via digital inputs/outputs (e.g.: Control Unit, TM31 or TB30) with the Braking Module.

In order to obtain the maximum power of a Braking Module, the Vdc_max control must be disabled.

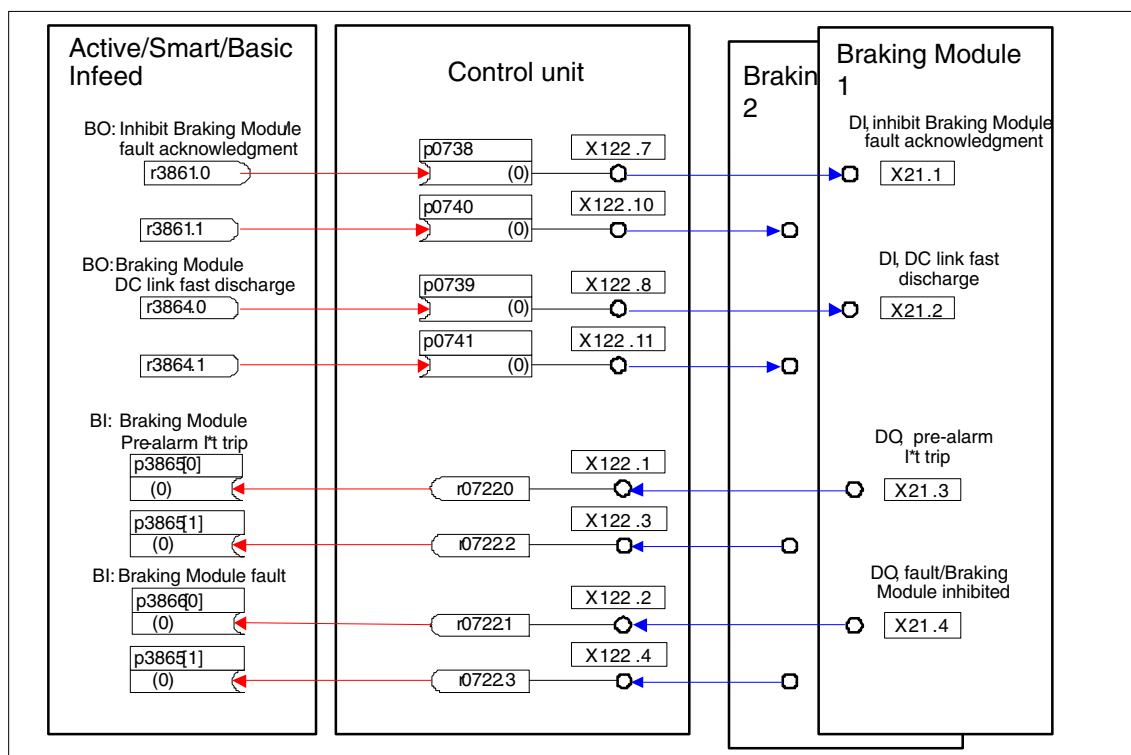


Fig. 4-17 Example of controlling two Booksize Braking Modules

Acknowledgement of faults

When the Braking Module issues a fault message at binector input p3866, an attempt is made to acknowledge the fault using signal p3861 at terminal X21.1 Booksize or X21.3 Chassis every 10 ms. Alarm A06900 is simultaneously is output.

Fast DC link discharge (booksize)

It is only possible to quickly discharge the DC link via the Braking Module for the booksize design. It is activated via binector input p3863 and started after the line contactor opens and the adjustable delay time (p3862) has expired. The fast discharge is completed when the line contactor contact closes.

Notice

Prerequisites for a fast DC link discharge is to use a line contactor with feedback signal (p0860) that is controlled via r0863.1.

Overview of important parameters (refer to the List Manual)

- r0108.26 Drive object function module – Braking Module
- p3860 Braking Module number of modules connected in parallel
- r3861 BO: Inhibit Braking Module
- p3862 Braking Module DC link fast discharge delay time
- p3863 BI: Braking Module activate DC link fast discharge
- p3864 BO: Braking Module DC link fast discharge
- p3865 BI: Braking Module pre-alarm I*t shutdown
- p3866 BI: Braking Module fault

Function diagram overview (refer to the List Manual)

- 9951 Braking Module interface via CU or parallel circuit

4.22 Function module "cooling system"

Features

- Control and monitoring functions of a cooling system
- Automatically activated when using water-cooled power units
- Evaluation of a leakage water sensor (p0266.4)
- Evaluation of a water flow sensor (p0266.5, p0260, p0263)
- Evaluation of a conductivity sensor sensor (p0266.6, p0266.7, p0261, p0262)
- Monitoring the water intake temperature using internal temperature sensors
- Monitoring the flow rating using internal temperature sensors

Description

A cooling system (RKA) is responsible for cooling the water and the (non) conductivity in the de-ionized water cooling circuit of a water-cooled power unit. The cooling system is controlled and monitored from a PLC that is part of the cooling system. The cooling system function module described here is used as an interface between the closed-loop control and the external control (open-loop) (PLC) of the cooling system. The cooling system is controlled via terminals (e.g. Control Unit, TM31).

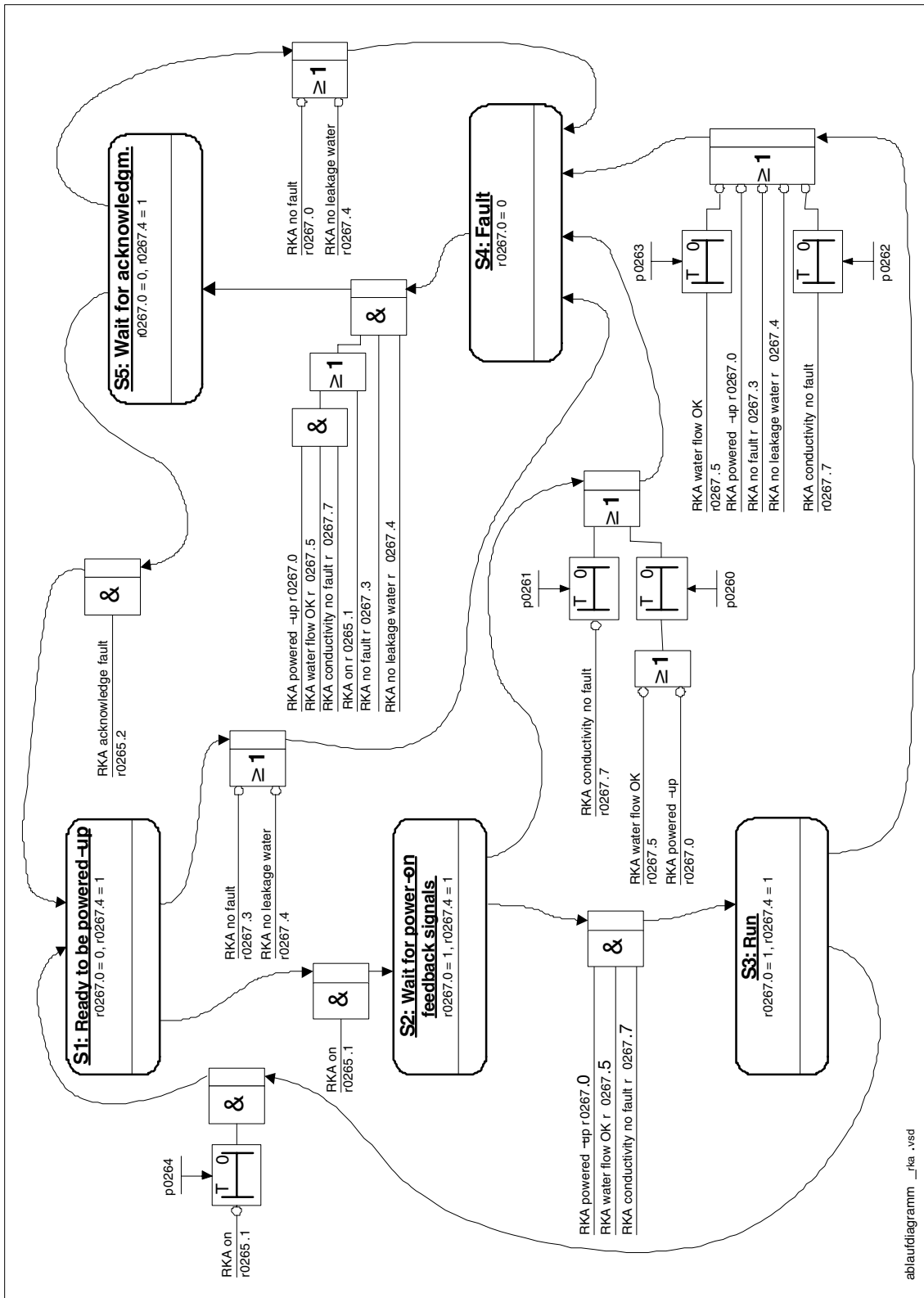


Fig. 4-18 Sequence control cooling system

Function diagram overview (refer to the List Manual)

- 9795 Cooling system sequence control

Overview of important parameters (refer to the List Manual)

- r0046.29 Missing enable signals – cooling system ready missing
- p0192.06 Power unit firmware properties – water cooling
- r0204.06 Power unit hardware properties – water cooling
- p0260 Cooling system, starting time 1
- p0261 Cooling system, starting time 2
- p0262 Cooling system fault conductivity delay time
- p0263 Cooling system fault water flow delay time
- p0264 Cooling system, run-on time
- r0265 BO: Cooling system control word
- p0266[0...7] BI: Cooling system signal source feedback signals
- r0267 BO: Cooling system status word display

4.23 Function module position control

4.23.1 General features

The position controller essentially comprises the following parts:

- Position actual value conditioning (including the lower-level measuring probe evaluation and reference mark search)
- Position controller (including limits, adaptation and the pre-control calculation)
- Monitoring functions (including standstill, positioning, dynamic following error monitoring and cam signals)
- There is still no position actual value conditioning for distance-coded measuring systems.

4.23.2 Integration

The position controller function module is integrated into the system as follows:

Commissioning

The function module “position control” can be activated via the commissioning Wizard or the drive configuration (configure DDS).

When the function module “basic positioner” (r0108.4 = 1) is activated, then the function module “position control” (r0108.3) is automatically activated.

The current configuration can be checked in parameter r0108.

The position controller can be parameterized in a user-friendly fashion using the screen forms in STARTER.

The position control function module must always be used when using the basic positioner function.

If the function module “position control” is active, and to optimize the speed controller, a function generator signal is interconnected to the speed controller input p1160, then the position controller monitoring functions respond. In order that this does not happen, the position controller must be disabled (p2550 = 0) and go into the tracking mode (p2655 = 1, for control using PROFIdrive telegram 110 PosSTW.0 = 1), so that the monitoring functions are disabled and the position set-point is tracked.

Function diagrams (refer to the List Manual)

- 4010 Position actual value conditioning
- 4015 Position controller
- 4020 Standstill/positioning monitoring
- 4025 Dynamic following error monitoring cam controller

4.23.3 Position actual value conditioning**Features**

- Correction value (p2512, p2513)
- Setting value (p2514, p2515)
- Position offset (p2516)
- Position actual value (r2521)
- Velocity actual value (r2522)
- Motor revolutions (p2504)
- Load revolutions (p2505)
- Spindle pitch (p2506)

Description

The position actual value conditioning implements the conditioning of the position actual value in a neutral position unit LU (LENGTH UNIT). To do this, the function block uses the encoder evaluation/motor control with the available encoder interfaces Gn_XIST1, Gn_XIST2, Gn_STW and Gn_ZSW. These just provide position information in encoder pulses and fine resolution (increments).

The position actual value is conditioned independently of whether the position controller is enabled immediately after the system has booted and as soon as valid values are received via the encoder interface.

Parameter p2502 (encoder assignment) is used to define from which encoder (1, 2 or 3), the position actual value is sensed.

The following interconnections are automatically established after the assignment has been made.

- p0480[0] (G1_STW) = encoder control word r2520[0]
- p0480[1] (G2_STW) = encoder control word r2520[1]
- p0480[2] (G3_STW) = encoder control word r2520[2]

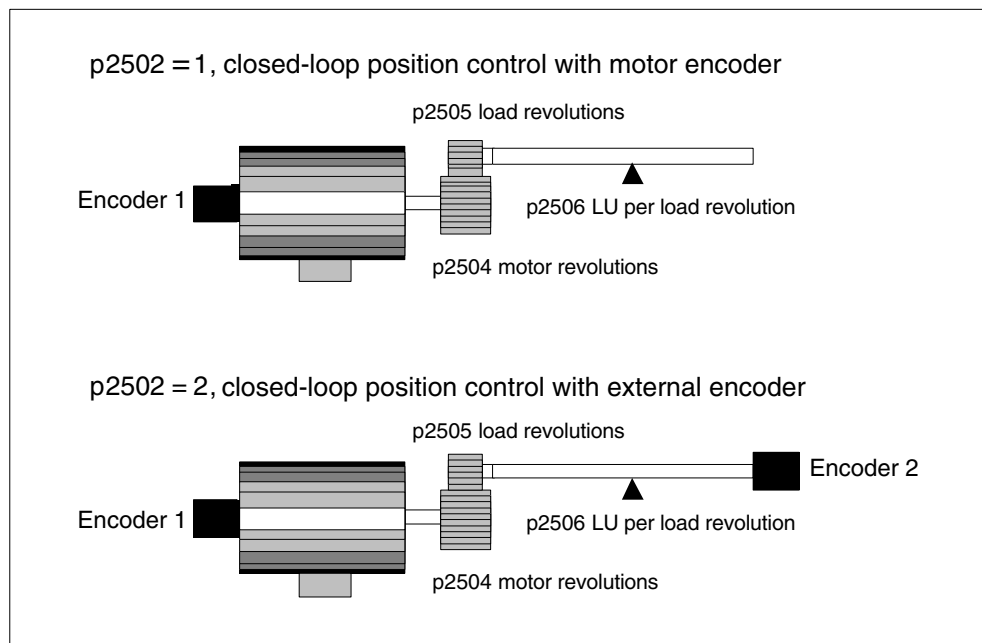


Fig. 4-19 Position actual value sensing using rotary encoders

The interrelationship between physical quantities and the neutral length unit LU is realized, for rotary encoders, using parameter $p2506$ (LU per load revolution). Parameter $p2506$ mirrors, together with $p2504$, $p2505$, the interrelationship between encoder increments and the neutral position unit LU.

Example:

Rotary encoder, ball screw with a pitch of 10 mm/revolution. 10 mm should have a resolution of $1 \mu\text{m}$ (i.e. $1 \text{ LU} = 1 \mu\text{m}$).

→ One load revolution corresponds to 10000 LU

→ $p2506 = 10000$

Note

The effective actual value resolution is obtained from the product of the encoder pulses ($p0408$) and the fine resolution ($p0418$) and a measuring gearbox that is possibly being used ($p0402$, $p0432$, $p0433$).

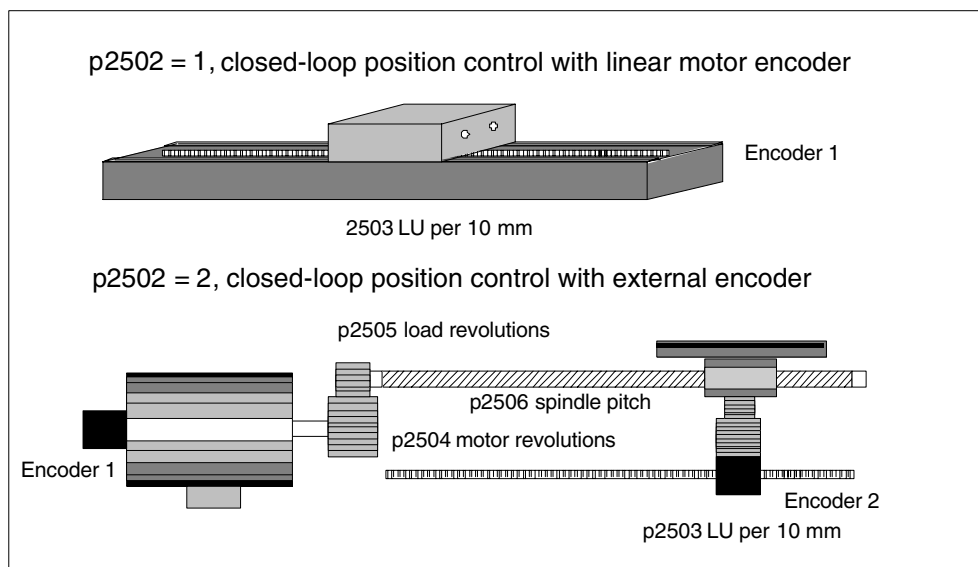


Fig. 4-20 Position actual value sensing with linear encoders

For linear encoders, the interrelationship between the physical quantity and the neutral length unit LU is configured using parameter p2503 (LU/10 mm).

Example:

Linear scale, 10 mm should have a resolution of 1 μm (i.e. 1 LU = 1 μm)

→ p2503 = 10000

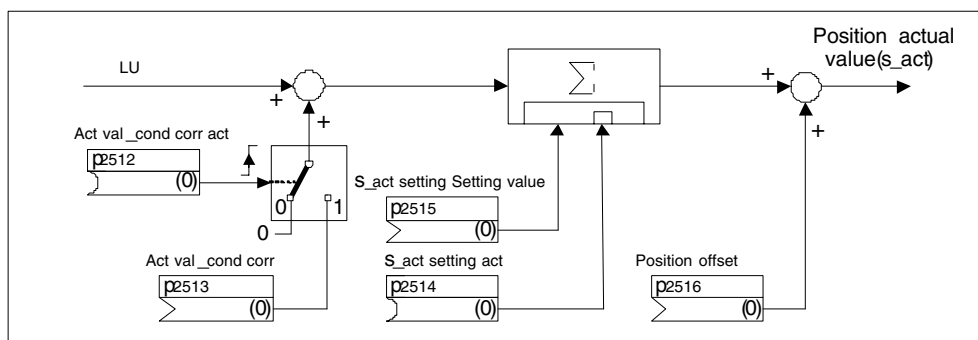


Fig. 4-21 Position actual value conditioning

A correction can be made using connector input p2513 (correction value, position actual value conditioning) and a positive edge at binector input p2512 (activates the correction value). When the function module “basic positioning” is activated, p2513 is automatically interconnected with r2685 (EPOS correction value) and p2512 with r2684.7 (activate correction). This interconnection implements the modulo correction of EPOS.

A position offset can be switched-in using p2516. Using EPOS, p1216 is automatically interconnected to r2667. Backlash compensation is implemented using this interconnection.

Using the connector input p2515 (position setting value) and a “1” signal at binector input p2514 (set position actual value), a position setting value can be entered.



Warning

By setting the position actual value (p2514 = “1” signal), the position actual value of the position control is held, as standard to the value of connector p2515. Encoder increments that are received are not evaluated. If there is a position difference, then in this state it cannot be corrected.

Parameter p0410 inverts the position actual value from the encoder. An inversion of the axis motion can be entered using a negative value in p2505.

Commissioning using STARTER

The function module “position control” can be activated via the commissioning Wizard or the drive configuration (configure DDS).

When the function module “basic positioner” (r0108.4 = 1) is activated, then the function module “position control” (r0108.3) is automatically activated.

The current configuration can be checked in parameter r0108.

Overview of important parameters (refer to the List Manual)

- p2502 LR encoder assignment
- p2503 LR length unit LU per 10 mm
- p2504 LR motor/load motor revolutions
- p2505 LR motor/load load revolutions
- p2506 LR length unit LU per load revolution
- r2520 CO: LR position actual value conditioning encoder control word
- r2521 CO: LR position actual value
- r2522 CO: LR velocity actual value
- r2523 CO: LR measured value
- r2524 CO: LR LU/revolutions
- r2525 CO: LR encoder adjustment offset
- r2526 CO/BO: LR status word

Overview, function diagrams (refer to the List Manual)

- 4010 Position actual value conditioning

4.23.4 Position controller

Features

- Symmetrization (p2535, p2536)
- Limiting (p2540, p2541)
- Pre-control (p2534)
- Adaptation (p2537, p2538)

Note

We only recommend that experts use the position controller functions without using the basic positioner.

Description

The position controller is a PI controller. The P gain can be adapted using the product of the connector input p2537 (adaptation position controller) and parameter p2538 (Kp).

Using connector input p2541 (limit), the speed setpoint of the position controller can be limited without pre-control. This connector input is pre-interconnected with connector output p2540.

The position controller is enabled via binector inputs p2549 (enable position controller 1) and p2550 (enable position controller 2) that are AND'ed with one another.

The position setpoint filter (p2533 time constant position setpoint filter) is a PT1 element, the symmetrizing filter as deadtime element (p2535 symmetrizing filter speed pre-control (deadtime) and PT1 element (p2536 symmetrizing filter speed pre-control (PT1))). The speed pre-control p2534 (factor, speed pre-control) can be disabled via the value 0.

Overview of important parameters (refer to the List Manual)

- p2533 LR position setpoint filter, time constant
- p2534 LR speed pre-control factor
- p2535 LR speed pre-control symmetrizing filter dead time
- p2536 LR speed pre-control symmetrizing filter PT1
- p2537 CI: LR Position controller adaptation
- p2538 LR proportional gain
- p2539 LR integral action time
- p2540 CO: LR position controller output speed limit
- p2541 CI: LR position controller output speed limit signal source

Function diagram (refer to the List Manual)

- 4015 Position controller

4.23.5 Monitoring functions

Features

- Standstill monitoring (p2542, p2543)
- Positioning monitoring (p2544, p2545)
- Dynamic following error monitoring (p2546, r2563)
- Cam controllers (p2547, p2548, p2683.8, p2683.9)

Description

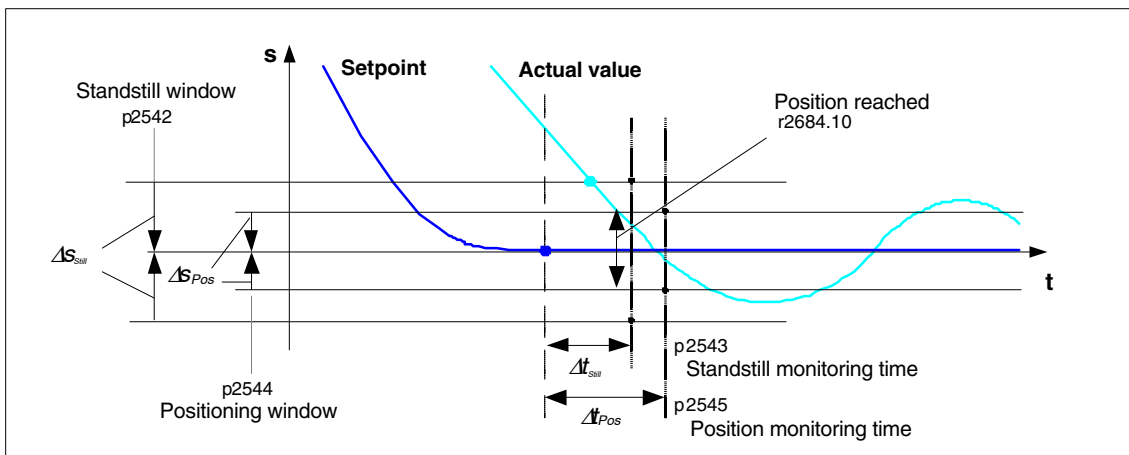


Fig. 4-22 Standstill monitoring, positioning window

The position controller monitors standstill (zero speed), the positioning and the following error.

The standstill monitoring function is activated using binector input p2551 (setpoint static) and p2542 (standstill window). If the standstill window has still not been reached when the monitoring time (p2543) has expired, fault F07450 is output. The positioning monitoring is activated using binector inputs p2551 (setpoint static) and p2554 = "0" (traversing command not active) and p2544 (positioning window). After the monitoring time (p2545) has expired, the positioning window is checked once. If it has not been reached, F07451 is output.

The standstill monitoring and the positioning monitoring can be de-activated using the value "0" in p2542 and p2544. The standstill window should be greater than or equal to the positioning window ($p2542 \geq p2544$). The standstill monitoring window should be less than or equal to the positioning monitoring time ($p2543 \leq p2545$).

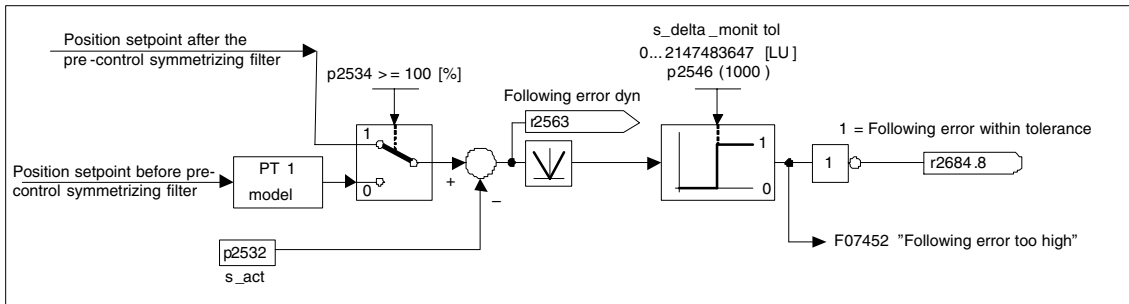


Fig. 4-23 Following error monitoring

The following error monitoring is activated using p2546 (tolerance, following error). If the absolute value of the dynamic following error (r2563) is greater than p2546, fault F07452 is output and bit r2648.8 is reset.

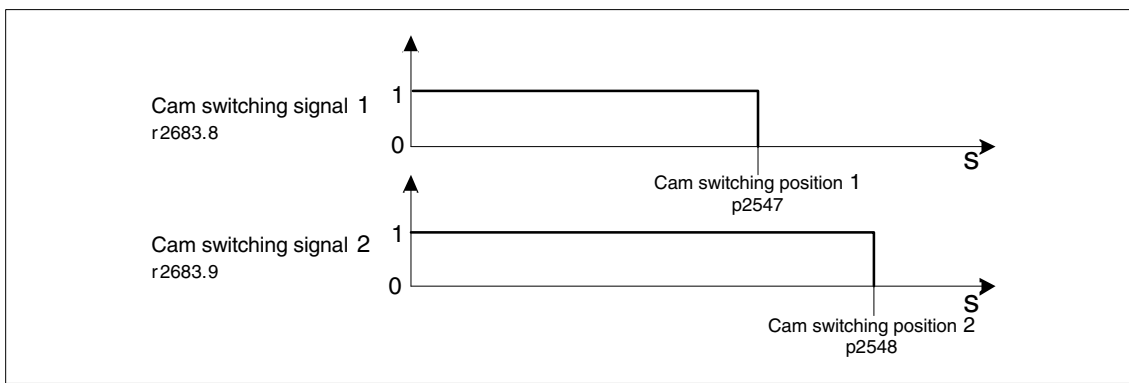


Fig. 4-24 Cam controllers

The position controller has two cam controllers. If cam position p2521 > p2547 or 2548), then cam signals r2683.8 and r2683.9 are reset.

Overview of important parameters (refer to the List Manual)

- p2530 CI: LR position setpoint
- p2532 CI: LR position actual value
- p2542 LR standstill window
- p2543 LR standstill monitoring time
- p2544 LR positioning window
- p2545 LR positioning monitoring time
- p2546 LR dynamic following error monitoring tolerance
- p2547 LR cam switching position 1
- p2548 LR cam switching position 2
- p2551 BI: LR signal setpoint static
- p2554 BI: LR signal traversing command active
- r2563 CO: LR following error actual
- r2683.8 Position actual value \leq cam switching position 1
- r2683.9 Position actual value \leq cam switching position 2
- r2684 CO/BO: EPOS status word 2

Function diagram (refer to the List Manual)

- 4020 Standstill/positioning monitoring
- 4025 Dynamic following error monitoring cam controller

4.23.6 Measuring probe evaluation and reference mark search

Description

The function "Reference mark search" and "Measuring probe evaluation" can be initiated and carried-out via binector input p2508 (activate reference mark search) and p2509 (activate measuring probe evaluation). In this case, binector input p2510 (measuring probe selection) and p2511 (measuring probe edge evaluation) define the module for the measuring probe evaluation. The appropriate function is started using a 0/1 edge at the appropriate input p2508 (activate reference mark search) or p2509 (activate measuring probe evaluation) via the encoder control word. Status bit r2526.1 (reference function) signals that the function is active (feedback from the encoder status word). Status bit r2526.2 (measured value valid) indicates the required measured value r2523 is available (position at the reference mark or at the measuring probe).

If the function has been completed (position at the reference mark or at the measuring probe has been determined) then r2526.1 (reference function active) and r2526.2 (measured value valid) are still active and the measured value is provided via r2523 (measured value referencing) until the appropriate input p2508 (activating reference mark search) or p2509 (activate measuring probe evaluation) is reset (0 signal).

If the function (reference mark search or measuring probe evaluation) has still not been completed and the corresponding input p2508 or p2509 is reset, then the function is interrupted via the encoder control word and status bit r2526.1 (reference function active) is reset via the encoder status word.

If both binector inputs p2508 and p2509 are simultaneously set, this causes the active function to be interrupted and no function is started. This is indicated using alarm A07495 "reference function interrupted" and remains until the signals at the binector inputs are reset. The alarm is also generated if, during an activated function (reference mark search or measuring probe evaluation) a fault is signaled using the encoder status word.

When selecting the function module "position control" these parameters (p2508 to p2511) are pre-assigned "0". If the function module "basic positioner" is selected, the functions "reference mark search" (for the function reference point search) and "measuring probe evaluation" (for the function flying referencing) are initiated by the function module basic positioner and the feedback signal (r2526, r2523) is fed back to this (also refer to: Commissioning Manual, Chapter "Control and status words for encoders").

Overview of important parameters (refer to the List Manual)

- p2508 BI: LR activate reference mark search
- p2509 BI: LR activate measuring probe evaluation
- p2510 BI: LR measuring probe evaluation, selection
- p2511 BI: LR measuring probe evaluation edge
- r2523 CO: LR measured value
- r2526 CO/BO: LR status word

Function diagram (refer to the List Manual)

- 4010 Position actual value conditioning
- 4720 Encoder interface, receive signals, encoder 1 ... 3
- 4730 Encoder interface, send signals, encoder 1 ... 3

4.24 Function module "basic positioner"

General description

The basic positioner is used to position linear and rotary axes (modulo) in absolute/relative terms with motor encoder (indirect measuring system) or machine encoder (direct measuring system). It is available in the servo and vector modes.

Further, user-friendly configuration, commissioning and diagnostic functions are available in STARTER for the basic positioner functionality (graphic navigation). In STARTER, there is a control panel for the basic positioner and speed-controlled operation; using this control panel, the functionality can be started from a PC/PG to commission the system or carry-out diagnostics.

When the basic positioner is activated ($r0108.4 = 1$), then the position control ($r0108.3 = 1$) should also be activated. This is realized automatically when activating the basic positioner via the commissioning Wizards of STARTER. Further, the necessary "internal interconnections" (BICO technology) are automatically established.

This means that naturally the position control functions are also available (e.g. standstill monitoring, positioning monitoring, dynamic following error monitoring, cam controllers, modulo function, measuring probe evaluation). Also refer to the section "Position control".

In addition, the following functions can be carried-out using the basic positioner:

- Mechanical system
 - Backlash compensation
 - Modulo correction
- Limits
 - Traversing profile limits
 - Traversing range limits
- Referencing or adjusting
 - Set reference point (for an axis at standstill that has reached its target position)
 - Reference point approach (autonomous mode including reversing cam functionality, automatic direction of rotation reversal, referencing to "cams and encoder zero mark" or only "encoder zero mark" or "external equivalent zero mark (BERO)")
 - Flying referencing (during the "normal" traversing motion, it is possible to reference, superimposed, using the measuring probe evaluation; generally, evaluating e.g. a BERO. Higher-level (superimposed) function for the modes "jog", direct setpoint input/MDI and "traversing blocks")

- Referencing with incremental measuring systems
- Absolute encoder adjustment
- Traversing blocks mode (64 traversing blocks)
 - Positioning using traversing blocks that can be saved in the drive unit including block change enable conditions and specific tasks for an axis that was previously referenced
 - Traversing block editor using STARTER
 - A traversing block contains the following information:
 - Task number
 - Task (e.g. positioning, wait, block jump GOTO, setting binary outputs)
 - Motion parameters (target position, velocity override for acceleration and deceleration)
 - Mode (e.g.: Skip block, block change enable conditions such as "Continue_with_stop" and "Continue_flying")
 - Task parameters (e.g. delay time, block jump conditions)
- Direct setpoint input (MDI) mode
 - Positioning (absolute, relative) and setting-up (endless closed-loop position control) using direct setpoint inputs (e.g. via the PLC or process data)
 - It is possible to continually influence the motion parameters while traversing (flying setpoint transfer) as well as flying change between the setting-up and positioning modes.
- Jog mode
 - Closed-loop position controlled traversing of the axis with the "endless position controlled" or "jog incremental" modes that can be toggled between (traverse through a "step width")
- Standard PROFIdrive positioning telegrams are available (telegrams 7 and 110) which when selected, automatically establish these internal "connection" to the basic positioner.
- In the present version (FM2.4), the adjustable "jerk" is still not available. If the traversing profile is to be rounded-off, the position setpoint smoothing (p2533) should be used.
- Control using PROFIdrive telegrams 7 and 110
(additional information, refer to the Commissioning Manual)

4.24.1 Mechanical system

Features

- Backlash compensation (p2583)
- Modulo correction (p2577)

Description

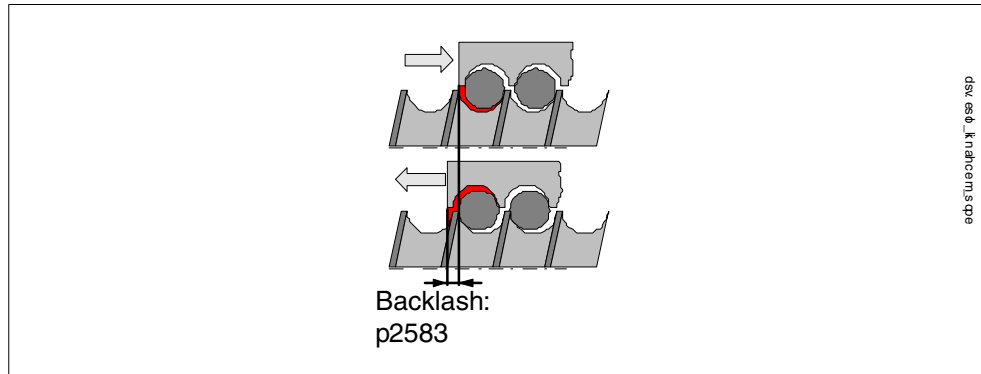


Fig. 4-25 Backlash compensation

When mechanical force is transferred between a machine part and its drive, generally backlash occurs. If the mechanical system was to be adjusted/adjusted so that there was absolutely no play, this would result in high wear. Thus, backlash (play) can occur between the machine component and the encoder. For axes with indirect position sensing, mechanical backlash results in a falsification of the traversing distance, as, at direction reversal, the axis travels either too far or not far enough corresponding to the absolute value of the backlash.

Note

The backlash compensation is active, after

- the axis has been referenced for incremental measuring systems
- the axis has been adjusted for absolute measuring systems

In order to compensate the backlash, the determined backlash must be specified in p2583 with the correct polarity. At each direction of rotation reversal, the axis actual value is corrected dependent on the actual traversing direction and displayed in r2667. This value is taken into account in the position actual value using p2516 (position offset).

If a stationary axis is referenced by setting the reference point or an adjusted axis is powered-up with an absolute encoder, then the setting of parameter p2604 (reference point approach, starting direction) is relevant for switching-in the compensation value.

Table 4-8 The compensation value is switched-in as a function of p2604

p2604	Traversing direction	Switch-in compensation value
0	positive	none
	negative	immediately
1	positive	immediately
	negative	none

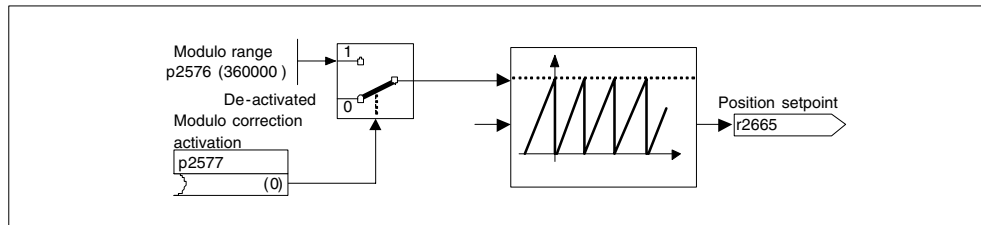


Fig. 4-26 Modulo correction

A modulo axis has an unrestricted traversing range. The value range of the position repeats itself after a specific value that can be parameterized (the modulo range or axis cycle), e.g. after one revolution: $360^\circ \rightarrow 0^\circ$. The modulo range is set in parameter p2576 and the correction is activated using parameter p2577. The modulo correction is carried-out on the setpoint side. This is provided with the correct sign via connector output r2685 (correction value) to appropriately correct the position actual value. EPOS initiates the activation of the correction via a rising edge of binector output r2684.7 (activate correction) (r2685 (correction value) and r2684.7 (activate correction) are already connected as standard with the corresponding binector/connector input of the position actual value conditioning). Absolute position data (e.g. in a traversing task) must be located within the modulo range. The modulo correction can be activated for both linear and rotary length units. The traversing range cannot be limited by a software limit switch.

Overview of important parameters (refer to the List Manual)

- p2576 EPOS modulo correction, modulo range
- p2577 BI: EPOS modulo correction, activation
- p2583 EPOS backlash compensation
- r2684 CO/BO: EPOS status word 2
- r2685 CO: EPOS correction value

Function diagrams (refer to the List Manual)

- 3635 Interpolator
- 4010 Position actual value conditioning

Commissioning using STARTER

In STARTER, the mechanical system screen form can be found under position control.

4.24.2 Limits

Description

The velocity, acceleration and deceleration can be limited and the software limit switches and stop cams set.

Features

- Traversing profile limits
 - Maximum velocity (p2571)
 - Maximum acceleration (p2572) / maximum deceleration (p2573)
- Traversing range limits
 - Software limit switch (p2578, p2579, p2580, p2581, p2582)
 - STOP cams (p2568, p2569, p2570)

Maximum velocity

The maximum velocity of an axis is defined using parameter p2571.
The velocity should not be set higher than the maximum speed in r1084 and r1087.

The drive is limited to this velocity if a higher velocity is specified or programmed via the override (p2646) for the reference point approach or is programmed in the traversing block.

Parameter p2571 (maximum velocity) defines the maximum traversing velocity in units 1000 LU/min. If the maximum velocity is changed, then this limits the velocity of a traversing task that is presently being executed.

This limit is only effective in the positioning mode for:

- Jog mode
- Processing traversing blocks
- Direct setpoint input/MDI for positioning/setting-up
- Reference point approach

Maximum acceleration/deceleration

Parameter p2572 (maximum acceleration) and p2573 (maximum deceleration) define the maximum acceleration and the maximum deceleration. In both cases, the units are 1000 LU/s².

Both values are relevant for:

- Jog mode
- Processing traversing blocks
- Direct setpoint input/MDI for positioning and setting-up
- Reference point approach

The parameters do not have any effect when faults occur with the fault responses OFF1 / OFF2 / OFF3.

In the traversing blocks mode, the acceleration and deceleration can be set in multiple integer steps (1 %, 2 % ... 100 %) of the maximum acceleration and deceleration. In the mode direct setpoint input/MDI for positioning and setting-up, the acceleration/deceleration override (assignment 4000Hex = 100 %) is entered.

Note

A maximum acceleration or deceleration dependent on the actual velocity (transitioned acceleration) is not supported.

Note

When using PROFIdrive telegram 110, the velocity override is already interconnected and must be supplied via the telegram.

Software limit switches

The connector inputs p2578 (software limit switch minus) and p2579 (software limit switch plus) limit the position setpoint if the following prerequisites are fulfilled:

- The software limit switches are activated (p2582 = "1")
- The reference point is set (r2684.11 = 1)
- The modulo correction is not active (p2577 = "0")

The connector inputs are, in the factory setting, linked to the connector output p2580 (software limit switch minus) and p2581 (software limit switch plus).

Stop cam

A traversing range can, on one hand, be limited per software using the software limit switches and on the other hand, the traversing range can be limited per hardware. In this case, the functionality of the stop cam (hardware limit switch) is used. The function of the stop cam is activated with the 1 signal at binector input p2568 (activate stop cam).

After the enable, the activity of the binector inputs p2569 (stop cam minus) and p2570 (stop cam plus) is checked. These are low active; this means if a 0 signal is present at binector input p2569 or p2570, then these are active.

When a stop cam (p2569 or p2570) is active, the actual motion is stopped with the maximum deceleration (p2573) and the appropriate status bit r2684.13 (stop cam minus active) or r2684.14 (stop cam plus active) is set.

When stop cams are actuated, only motion that allows the axis to move away from the stop cam is permitted (if both stop cams are actuated, then no motion is possible). When the stop cam is exited, this is identified by the 0/1 edge in the permitted traversing direction and this means that the corresponding status bits (r2684.13 or r2684.14) are reset.

Overview of important parameters (refer to the List Manual)

- p2571 EPOS maximum velocity
- p2572 EPOS maximum acceleration
- p2573 EPOS maximum deceleration
- p2646 CI: EPOS velocity override

Software limit switch:

- p2578 CI: EPOS software limit switch minus signal source
- p2579 CI: EPOS software limit switch plus signal source
- p2580 CO: EPOS software limit switch minus
- p2581 CO: EPOS software limit switch plus
- p2582 BI: EPOS software limit switch activation
- r2683 CO/BO: EPOS status word 1

STOP cam

- p2568 BI: EPOS STOP cam activation
- p2569 BI: EPOS STOP cam minus
- p2570 BI: EPOS STOP cam plus
- r2684 CO/BO: EPOS status word 2

Function diagram overview (refer to the List Manual)

- 3630 Traversing range limits

4.24.3 Referencing

Features

- Reference point offset (p2600)
- Changeover cam (p2613, p2614)
- Reference cam (p2612)
- Binector input start (p2695)
- Binector input setting (p2596)
- Velocity override (p2646)
- Reference point coordinate (p2598, p2599)
- Selecting the referencing type (p2597)
- Absolute encoder adjustment (p2507)

Notice

Referencing distance-coded zero marks is not supported.

Description

After a machine has been powered-up, for positioning, the absolute dimension reference must be established to the machine zero. This operation is known as referencing.

The following referencing types are possible:

- Setting the reference point (all encoder types)
- Incremental encoders
 - Active referencing (reference point approach (p2597 = 0)):
 - Reference cams and encoder zero mark (p2607 = 1)
 - Encoder zero mark (p0495 = 0)
 - External zero mark (p0495 ≠ 0)
 - Flying referencing (passive (p2597 = 1))
- Absolute encoder
 - Absolute encoder adjustment
 - Flying referencing (passive (p2597 = 1))

A connector input is provided for all referencing types to input the reference point coordinate; this allows, e.g. the change/input via the higher-level control. However, to permanently enter the reference point coordinate, a setting parameter for this quantity is also required. As standard, this setting parameter p2599 is interconnected to connector input p2598.

Set reference point

The reference point can be set using a 0/1 edge at binector input p2596 (set reference point) if a traversing command is not active or was interrupted by an intermediate stop and the drive is operational. The coordinate in p2598 is transferred into the actual position and becomes valid as reference point.

As standard, connector input p2598 is connected to setting parameter p2599. The binector input is not effective for the traversing task being presently executed.

Absolute encoder adjustment

Absolute encoders must be adjusted while commissioning. After the machine has been powered-down the position information of the encoder is kept.

When p2507 = 2 is entered, using the reference point coordinate in p2599, an offset value (p2525) is determined; this is used to calculate the position actual value (r2521). Parameter p2507 signals the adjustment with a "3" – in addition bit r2684.11 (reference point set) is set to "1".

The offset of the encoder adjustment (p2525) should be saved in a non-volatile fashion (RAM to ROM) to permanently save it.



Caution

After the encoder has been adjusted, it must be ensured that the absolute encoder does not overflow along the complete traversing range. If an overflow occurs, then there is no clear reference any longer between the encoder actual value and the mechanical system.

Reference point approach for incremental measurement systems

When the reference point approach (in the case of an incremental measuring system), the drive is moved to its reference point. In so doing, the drive itself controls and monitors the complete referencing cycle.

Incremental measuring systems require that after the machine has been powered up, the absolute dimension reference is established to the machine zero point.

When powering-up the position actual value x_0 in the non-referenced state is set to $x_0 = 0$. Using the reference point approach, the drive can be reproducibly moved to its reference point. The geometry with a positive starting direction ($p2604 = "0"$) is shown in the following.

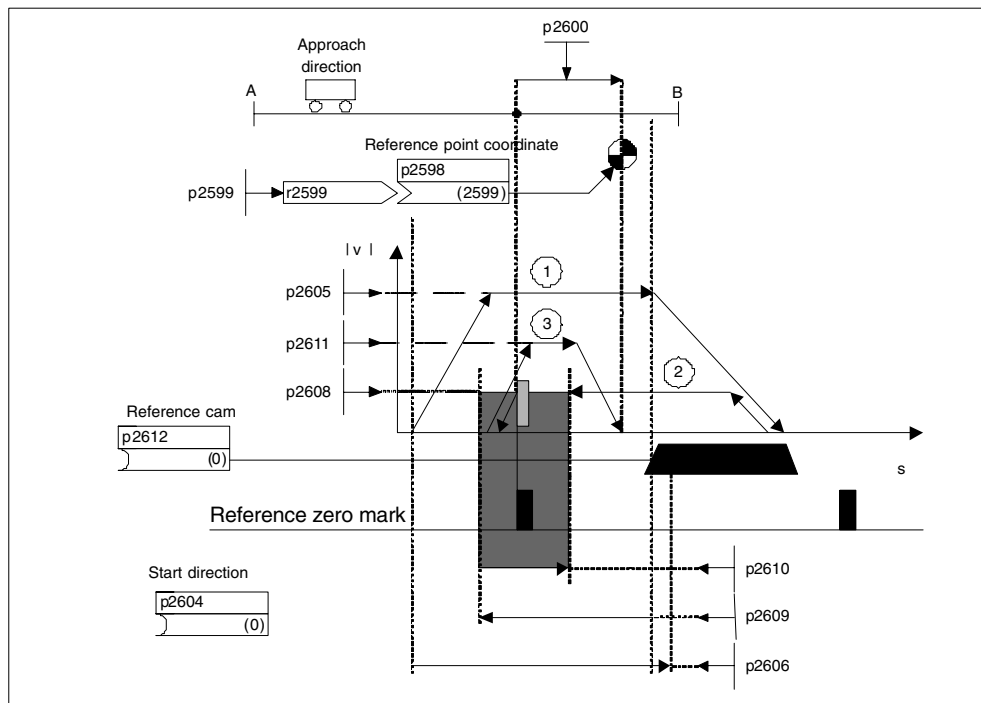


Fig. 4-27 Example, reference point approach using reference cams

Travel to the reference cam is initiated using the signal at binector input p2595 (start referencing) when the reference point approach is simultaneously selected (0 signal at binector input p2597 (select referencing type)) ($p2607 = 1$). During the complete referencing operation, the signal at binector input p2595 (start referencing) must be set otherwise referencing is interrupted. As a result of the start, status signal r2684.11 (reference point set) is reset.

The software limit switch monitoring is inactive during the complete reference point approach; only the maximum traversing range is checked. The SW limit switch monitoring is, if required, re-activated after completion.

The selected velocity override is effective only while searching for the reference cam (stop 1). This means that the positions "end of cam" and "zero mark" are always passed with the same velocity. If signal run times (propagation times) occur for the switching operations, then it is guaranteed that the offset that occurs when determining the position is the same at every referencing operation.

Axes that only have one zero mark over their complete traversing or modulo range are designated with parameter $p2607 = 0$ (no reference cam present). For these axes, after referencing has been started, a start is immediately made to synchronize to the reference zero mark (refer to step 2).

Reference point approach, step 1: Travel to the reference cam

If there is no reference cam ($p2607 = 0$), go to step 2.

When starting referencing, the drive accelerates, with the maximum acceleration ($p2572$) to the reference cam approach velocity ($p2605$). The approach direction is defined using the signal of the binector input $p2604$ (reference point approach, start direction).

When the reference cam is reached, this is communicated to the drive using the signal at binector input $p2612$ (reference cam); the drive then brakes down to standstill with the maximum deceleration ($p2573$).

If, during the reference point approach, a signal is detected at binector input $p2613$ (reversing cam, minus) or at binector input $p2614$ (reversing cam, plus), then the search direction is reversed. The reversing cams are low active. If both reversing cams are active ($p2613 = "0"$ and $p2614 = "0"$), then the drive remains stationary (zero speed). As soon as the reference cam is found, then synchronization to the reference zero mark is immediately started (refer to step 2).

If the axis moves from the starting position towards the reference cam, a distance defined in parameter $p2606$ (max. distance to the reference cam) without the reference cam being reached, the drive comes to a standstill and fault F07458 (reference cam not found) is output.

If the axis is already located at the cam, when referencing is started, then traversing to the reference cam is not executed, but synchronization to the reference zero mark is immediately started (refer to step 2).

Note

Velocity override is effective while traversing to the cam.

By changing the encoder data set, status signal r2684.11 (reference point set) is reset.

The cam switch must be able to supply both a rising as well as also a falling edge. For a reference point approach with evaluation of the encoder zero mark, for increasing position actual values the 0/1 edge is evaluated and for decreasing position actual values, the 1/0 edge. It is not possible to invert the edge evaluation for the encoder zero mark.

If the length measuring system has several zero marks that are repeated in cyclic intervals (e.g. an incremental, rotary measuring system), it must be carefully ensured that the cam is adjusted so that always the same zero mark is evaluated. The following factors can influence the behavior of the control signal "reference cam":

- switching accuracy and time delay of the reference cam switch
 - position controller clock cycle of the drive
 - interpolation clock cycle of the drive
 - temperature characteristics of the mechanical machine system
-

Reference point approach, step 2: Synchronizing to the reference zero mark (encoder zero mark or external zero mark)

Reference cam available (p2607 = 1):

In step 2, the drive accelerates to the velocity, specified in p2608 (zero mark approach velocity) in the direction opposite to that specified using binector input p2604 (reference point approach start direction). The zero mark is expected at a distance p2609 (max. distance to the zero mark). The search for the zero mark is active (status bit r2684.0 = "1" (reference point approach active)), as soon as the drive leaves the cam (p2612 = "0") and it is located within the tolerance bandwidth for the evaluation (p2609 – p2610). If the zero mark position is known (encoder evaluation), then actual drive position can be synchronized with the zero mark. The drive starts its reference point approach (refer to step 3). The distance moved between the end of the cam and the zero mark is displayed in diagnostics parameter r2680 (difference between the cam – zero mark).

Encoder zero mark available (p0495 = 0), no reference cam (p2607 = 0):

Synchronization to the reference zero mark starts immediately after the signal at binector input p2595 is detected (start referencing). The drive accelerates to the velocity, specified in parameter p2608 (zero mark approach velocity) in the direction specified by the signal of binector input p2604 (reference point approach start direction).

The drive synchronizes to the first zero mark. The drive continues to travel with the same velocity and travel is started to the reference point (refer to step 3).

Note

The approach direction to the reference zero mark is, in this case, opposite to that for axes with reference cam!

External zero mark available ($p0495 \neq 0$), no reference cam ($p2607 = 0$):

Synchronization to an external zero mark starts immediately after the signal at binector input p2595 is detected (start referencing). The drive accelerates to the velocity, specified in parameter p2608 (zero mark approach velocity) in the direction specified by the signal of binector input p2604 (reference point approach start direction). The drive synchronizes to the first external zero mark (p0495). The drive continues to travel with the same velocity and travel is started to the reference point (refer to step 3).

Note

The velocity override is not effective.

An equivalent zero mark can be set using parameter p0495 (equivalent zero mark input terminal) and the corresponding digital input selected. As standard, for increasing actual position values, the 0/1 edge is evaluated and for decreasing position actual values, the 1/0 edge. For the equivalent zero mark, this can be inverted using parameter p0490 (invert measuring probe or equivalent zero mark).

Reference point approach, step 3: Travel to reference point

After the drive has successfully synchronized itself to the reference zero mark, the travel to the reference point is started, (refer to step 2) After the reference zero mark has been detected, the drive accelerates, flying, to the reference point approach velocity set in parameter p2611. The axis moves through the reference point offset (p2600) – the distance between the zero mark and the reference point. If the axis has reached the reference point, then the position actual value and set-point are set to the value specified using connector input p2598 (reference point coordinate) (as standard, connector input p2598 is connected with setting parameter p2599). The axis is then referenced and status signal r2684.11 is set (reference point set).

Note

The velocity override is not effective.

If the braking distance is longer than the reference point offset or a direction reversal is required as a result of the selected reference point offset, then after detecting the reference zero mark, the drive initially brakes to standstill and then travels back.

Flying referencing

The mode "flying referencing" (also known as post-referencing, positioning monitoring), which is selected using a "1" signal at binector input p2597 (select referencing type), can be used in every mode (jogging, traversing block and direct setpoint input for positioning/setting-up) and is superimposed on the currently active mode. The flying referencing can be selected both for incremental as well as for absolute measuring systems.

For "flying referencing" while incrementally positioning (relative), it can be selected as to whether the correction value for the traversing distance should be taken into account or not (p2603).

The "flying referencing" is activated by a 0/1 edge at binector input p2595 (start referencing). During the complete referencing operation, the signal at binector input p2595 (start referencing) must be set otherwise referencing is interrupted.

Status bit r2684.1 (passive/flying referencing active) is connected with binector input p2509 (activate measuring probe evaluation) – it activates the measuring probe evaluation. Binector inputs p2510 (measuring probe selection) and p2511 (measuring probe edge evaluation) can be used to set which measuring probe (1 or 2) and which measuring edge (0/1 or 1/0) is used.

The connector input p2660 (measured value, referencing) is supplied with the measured value via parameter r2523 when the measuring probe pulse is received. The validity of the measured value is signaled using r2526.2 at binector input p2661 (measured value, valid feedback signal).

The the following happens:

- If the drive has still not been referenced status bit r2684.11 (reference point set) is set to "1".
- If the drive has already been referenced, at the start of the flying referencing, status bit r2684.11 (reference point set) is not reset.
- If the drive has already been referenced and if the absolute value of the position difference is less than the inner window (p2601), then the old position actual value is kept.
- If the drive has already been referenced and the absolute value of the position difference is greater than the outer window (p2602), alarm A07489 (reference point correction outside window 2) is output and status bit r2684.3 (print mark outside window 2) is set. The position actual value is not corrected.
- If the drive has already been referenced and the absolute value of the position difference is greater than the inner window (p2601) and less the outer window (p2602), then the position actual value is corrected.

Note

Flying referencing is not an active mode, it is superimposed on an active mode. Contrary to a reference point approach, flying referencing can be carried-out superimposed on the machine sequence.

As standard, for flying referencing, measuring probe evaluation is used; when enabled, the measuring probe is selected (p2510) and the edge evaluation (p2511) (in the factory setting, measuring probe 1 is always the measuring probe, flank evaluation in the factory setting is always the 0/1 edge).

Overview of important parameters (refer to the List Manual)

- p2596 BI: EPOS set reference point
- p2597 BI: EPOS referencing type selection
- p2598 CI: EPOS reference point coordinate, signal source
- p2599 CO: EPOS reference point coordinate value
- p2600 EPOS reference point approach, reference point offset

Function diagrams (refer to the List Manual)

- 3612 Referencing
- 3614 Flying referencing

4.24.4 Traversing blocks

Description

Up to 64 different traversing tasks can be saved. The maximum number is set using parameter p2615 (maximum number of traversing tasks).

All of the parameters that describe a traversing task are effective when a block is changed, i.e. if:

- The appropriate block number is selected using binector inputs p2625 to p2630 (block selection, bits 0...5) and started using the signal at binector input p2531 (activate traversing task).
- A block change is made in a sequence of traversing tasks.

Traversing blocks are parameterized using parameter sets that have a fixed structure:

- Block number (p2616[0...63])

Every traversing block must be assigned a task number (in STARTER "No."). The traversing blocks are executed in the sequence of the block numbers. Numbers with task number -1 are ignored, in order to e.g. reserve space for additional traversing blocks at a later stage.

- Task (p2621[0...63])

1: POSITIONING
 3: ENDLESS_POS
 4: ENDLESS_NEG
 5: WAIT
 6: GOTO
 7: SET_O
 8: RESET_O

- Motion parameters

- Target position or traversing distance (p2617[0...63])
- Velocity (p2618[0...63])
- Acceleration override (p2619[0...63])
- Deceleration override (p2620[0...63])

- Task mode (p2623[0...63])

The execution of a traversing task can be influenced by parameter p2623 (task mode). This is automatically written by programming the traversing blocks in STARTER.

Value = 0000 cccc bbbb aaaa

- aaaa: Display/suppress
 - 0000: Block is not suppressed
 - 0001: Block is suppressed
- bbbb: Advance condition

0000, END: 0/1 edge at p2631

0001, CONTINUE_WITH_STOP:

The position parameterized in the block is precisely approached (braking to standstill and positioning window monitoring) before block processing is continued.

0010, CONTINUE_FLYING:

A flying change is made into the next traversing block when the starting of braking of the current block is reached (if the direction has to be reversed, then the change is only made when stopped in the positioning window).

– cccc: Positioning mode

Defines, for the task POSITONING (p2621 = 1), how the position, specified in the traversing task, should be approached.

0000, ABSOLUTE: The position specified in p2617 is approached

0001, RELATIVE: The axis is moved through the value in p2617.

0010, ABS_POS: Only for rotary axes with modulo correction! The position specified in p2617 is approached in the positive direction.

0011, ABS_NEG: Only for rotary axes with modulo correction! The position specified in p2617 is approached in the negative direction.

- Task parameter (command-dependent significance) (p2622[0...63])

Immediate stop and reject traversing task

The intermediate stop is activated when a 0 signal at p2640. After activation, the axis is braked with the parameterized deceleration (p2620 or p2645).

The current traversing task can be rejected with a 0 signal at p2641. After activation, the axis is braked with the maximum deceleration (p2573).

The functions "intermediate stop" and "reject traversing task" are only effective in the modes "traversing blocks" and "direct setpoint input/MDI".

POSITIONING

The POSITIONING task initiates motion. The following parameters are evaluated:

- p2616[x] Block number
- p2617[x] Position
- p2618[x] Velocity
- p2619[x] Acceleration override
- p2620[x] Acceleration override
- p2623[x] Task mode

The task is executed until the target position is reached. If, when the task is activated, the drive is already located at the target position, then for the block change enable (CONTINUE_FLYING, the text task is selected in the same interpolation clock cycle. For CONTINUE_WITH_STOP, the next block is activated in the next interpolation clock cycle.

ENDLESS POS, ENDLESS NEG

Using these tasks, the axis is accelerated to the specified velocity and is moved, until:

- A software limit switch is reached
- The traversing range limit is reached
- Motion is interrupted by the control signal "no intermediate stop/intermediate stop (p2640)
- Motion is interrupted by the control signal "do not reject traversing task/reject traversing task" (p2641)

The following parameters are relevant:

- p2616[x] Block number
- p2618[x] Velocity
- p2619[x] Acceleration override
- p2623[x] Task mode

WAITING

Using the WAIT task, a delay time can be inserted, which must first expire before processing/executing the following task.

The following parameters are relevant:

- p2616[x] Block number
- p2622[x] Task parameter = delay time in milliseconds ≥ 0 ms
- p2623[x] Task mode

The delay time is entered in milliseconds – but is rounded-off to a multiple of the interpolator clock cycles p0115[5]. The minimum delay time is one interpolation clock cycle; this means that if a delay time is parameterized, which is less than an interpolation clock cycle, then the system waits for one interpolation clock cycle.

Example:

Delay time:	9 ms
Interpolation clock cycle:	4 ms
Effective delay time:	12 ms

Independent of the parameterized advance condition of the task that preceded the WAIT task, there, a precise stop is always executed before the delay time runs.

Possible advance conditions include END and CONTINUE_WITH_STOP.

GOTO

Using the GOTO task, jumps can be executed within a sequence of traversing tasks. The block number which is to be jumped to must be specified as task parameter. A condition to advance is not permissible. If there is a block with this number, then alarm A07468 (jump destination does not exist in traversing block x) is output and the block is designated as being inconsistent.

The following parameters are relevant:

- p2616[x] Block number
- p2622[x] Task parameter = Next task number

In one interpolation clock cycle, any two tasks SET_O, RESET_O and GOTO can be processed and a subsequent task POSITIONING and WAIT are started.

SET_O, RESET_O

The tasks SET_O and RESET_O allow up to two digital outputs to be simultaneously set or reset. The number of the output (1 or 2) is specified bit-coded in the task parameter.

The following parameters are relevant:

- p2616[x] Block number
- p2622[x] Task parameter = Bit-coded output:
0x1: Output 1
0x2: Output 2
0x3: Output 1 + 2

Possible conditions to advance include END, CONTINUE_FLYING and CONTINUE_WITH_STOP.

The set output 1 (or 2), then a digital output must be interconnected to parameter r2683.10 (direct output 1) (or r2683.11 (direct output 2)). The assignment in STARTER is made using the button "configuration digital output".

Any two tasks SET_O, RESET_O and GOTO can be processed in an interpolation clock cycle and a subsequent task POSITIONING and WAIT started.

Overview of important parameters (refer to the List Manual)

- p2616 EPOS traversing block, block number
- p2617 EPOS traversing block, position
- p2618 EPOS traversing block, velocity
- p2619 EPOS traversing block, acceleration override
- p2620 EPOS traversing block, deceleration override
- p2621 EPOS traversing block, task
- p2622 EPOS traversing block, task parameter
- p2623 EPOS traversing block, task mode
- p2625...p2630 BI: EPOS block selection bits 0 ... 5

Function diagrams (refer to the List Manual)

- 3616 Operating mode traversing blocks

4.24.5 Direct setpoint input (MDI)

Features

- Select direct setpoint input (p2647)
- Select positioning type (p2648)
- Direction selection (p2651, p2652)
- Setting-up (p2653)
- Fixed setpoints
 - CO: Position setpoint (p2690)
 - CO: Velocity setpoint (p2691)
 - CO: Acceleration override (p2692)
 - CO: Deceleration override (p2693)
- Connector inputs
 - CI: MDI position setpoint (p2642)
 - CI: MDI velocity setpoint (p2643)
 - CI: MDI acceleration override (p2644)
 - CI: MDI deceleration override (p2645)
 - CI: Velocity override (p2646)
- Accept (p2649, p2650)

Description

The function direct setpoint input allows positioning (absolute, relative) and setting up (endless, position controlled) using direct setpoint inputs (e.g. via the PLC using process data).

Further, during traversing motion, it is possible to influence motion parameters (flying setpoint transfer); it is also possible to make a flying change between the setting-up and positioning modes.

The mode direct setpoint input (MDI) can also be used if the axis is not referenced in the setting-up or relative positioning modes, so that using "flying referencing" (refer to the separate section), flying synchronization and post-referencing are possible.

The function direct setpoint input is activated using $p2647 = 1$. A differentiation is made between two modes – the mode positioning ($p2653 = 0$) and the mode setting-up ($p2653 = 1$).

In the positioning mode, using parameters (position, velocity, acceleration and deceleration) absolute ($p2648 = 1$) or relative ($p2648 = 0$) positioning can be carried out.

In the setting-up mode, using parameters (velocity, acceleration and deceleration) "endless" closed-loop position control behavior can be carried-out.

It is possible to make a flying changeover between the two modes.

When continuous transfer ($p2649 = 1$) is activated, changes to the MDI parameters are immediately accepted. Otherwise, the values are only accepted after a positive signal edge at binector input $p2650$ (setpoint transfer edge).

The positioning direction can be specified using $p2651$ (positive direction) and $p2652$ (negative direction). If both inputs have the same state, then for absolute positioning ($p2648 = "1"$) modulo axes ($p2577 = "1"$) are moved through the shortest distance.

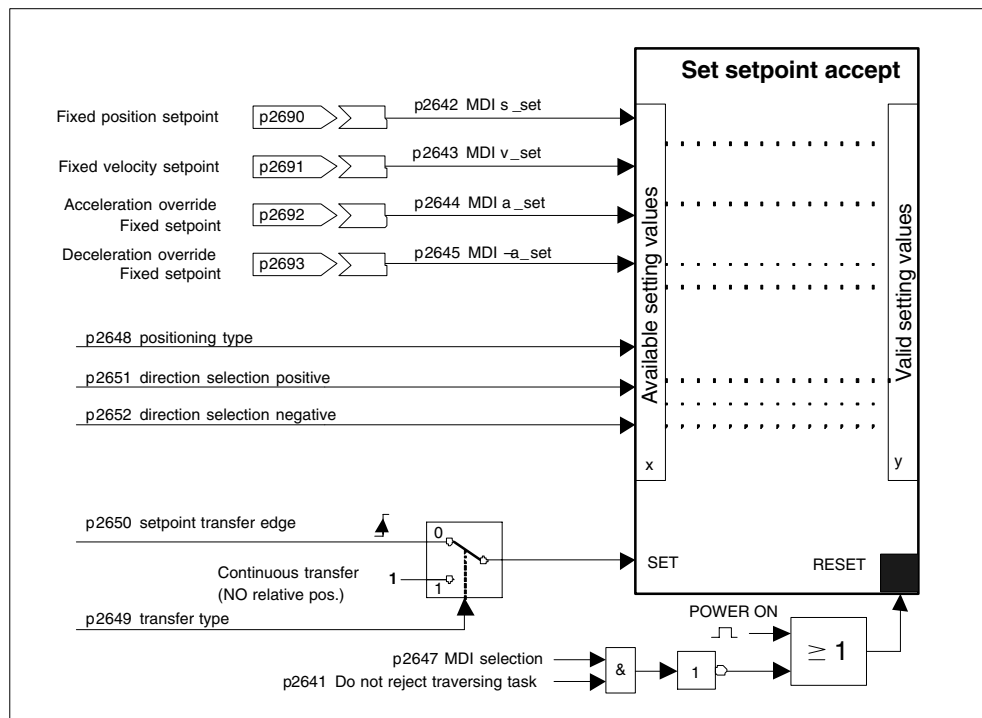


Fig. 4-28 Setpoint transfer

Immediate stop and reject traversing task

The intermediate stop is activated when a 0 signal at p2640. After activation, the axis is braked with the parameterized deceleration (p2620 or p2645).

The current traversing task can be rejected with a 0 signal at p2641. After activation, the axis is braked with the maximum deceleration (p2573).

The functions "intermediate stop" and "reject traversing task" are only effective in the modes "traversing blocks" and "direct setpoint input/MDI".

Overview of important parameters (refer to the List Manual)

- p2577 BI: EPOS modulo correction, activation
- p2642 CI: EPOS direct setpoint input/MDI position setpoint
- p2643 CI: EPOS direct setpoint input/MDI velocity setpoint
- p2644 CI: EPOS direct setpoint input/MDI acceleration override
- p2645 CI: EPOS direct setpoint input/MDI deceleration override
- p2648 BI: EPOS direct setpoint input/MDI positioning type
- p2649 BI: EPOS direct setpoint input/MDI transfer type
- p2650 BI: EPOS direct setpoint input/MDI setpoint transfer edge
- p2651 BI: EPOS direct setpoint input/MDI direction selection positive
- p2652 BI: EPOS direct setpoint input/MDI direction selection negative
- p2653 BI: EPOS direct setpoint input/MDI setting-up selection
- p2654 CI: EPOS direct setpoint input/MDI mode adaptation
- p2690 CO: EPOS position fixed setpoint
- p2691 CO: EPOS velocity fixed setpoint
- p2692 CO: EPOS acceleration override fixed setpoint
- p2693 CO: EPOS deceleration override fixed setpoint

Function diagram overview (refer to the List Manual)

- 3618 EPOS – operating mode direct setpoint input/MDI, dynamic values
- 3620 EPOS – operating mode direct setpoint input/MDI

4.24.6 Jog

Features

- Jog signals (p2589, p2590)
- Velocity (p2585, p2586)
- Incremental (p2587, p2588, p2591)

Description

Using parameter p2591 it is possible to change over between jog incremental and jog velocity.

The traversing distances p2587 and p2588 and velocities p2585 and p2586 are entered using the jog signals p2589 and p2590. The traversing distances are only effective for a "1" signal at p2591 (jog, incremental). For p2591 = "0" then the axis moves to the start of the traversing range or the end of the traversing range with the specified velocity.

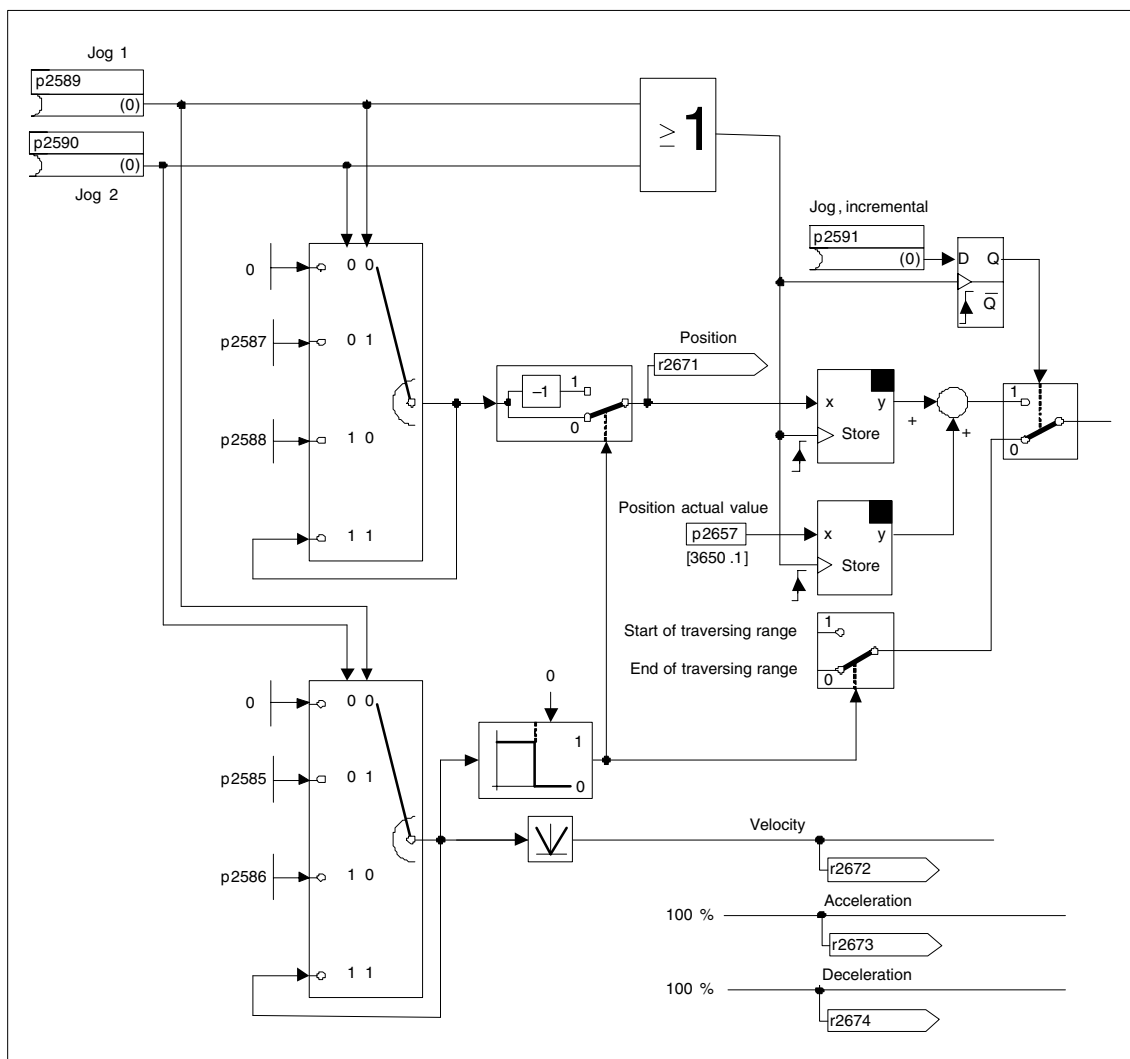


Fig. 4-29 Jog mode

Overview of important parameters (refer to the List Manual)

- p2585 EPOS jog 1 setpoint velocity
- p2586 EPOS jog 2 setpoint velocity
- p2587 EPOS jog 1 traversing distance
- p2588 EPOS jog 2 traversing distance
- p2589 BI: EPOS jog 1 signal source
- p2590 BI: EPOS jog 2 signal source
- p2591 BI: EPOS jog incremental

Function diagrams (refer to the List Manual)

- 3610 EPOS – jog mode

4.24.7 Status signals

The status signals relevant for positioning are described in the following.

Tracking mode active (r2683.0)

The status signal "tracking active" indicates that a tracking mode has been assumed that is possible using binector input p2655 "tracking" or as a result of a fault. In this status, the position setpoint tracks the position actual value, i.e. the position setpoint = position actual value.

Setpoint static (r2683.2)

The status signal "setpoint static" indicates that the setpoint velocity has a value of 0. The actual velocity can deviate from zero due to a following error. While the status word has a value of 0, a traversing task is being processed.

Traversing command active (r2684.15)

The status signal "traversing command active" indicates that a traversing command is active. A traversing command includes all traversing motion (also jogging, setting-up etc.). Contrary to the status signal "setpoint static", the status signal remains active – e.g. if a traversing command was stopped by a velocity override or intermediate stop.

SW limit switch + reached (r2683.7)
SW limit switch – reached (r2683.6)

These status signals indicate that the parameterized negative p2578/p2580 or positive p2579/p2581 traversing range limit was reached or passed. If both status signals are 0, the drive is located within the traversing limits.

Stop cam minus active (r2684.13)
Stop cam plus active (r2684.14)

These status signals indicate that the stop cam minus p2569 or stop cam plus p2570 were reached or passed. The signals are reset if the cams are left in a directly opposing the approach direction.

Axis moves forwards (r2683.4)
Axis moves backwards (r2683.5)
Axis accelerates (r2684.4)
Drive decelerates (r2684.5)
Drive stationary (zero speed) (r2199.0)

These signals display the current motion status. If the actual absolute speed is less or equal to p2161, then the status signal "drive stationary" is set – otherwise it is deleted. The signals are appropriately set if jog mode, reference point approach or a traversing task is active.

Cam switching signal 1 (r2683.8)
Cam switching signal 2 (r2683.9)

The electronic cam function can be implemented using these signals. Cam switching signal 1 is 0 if the actual position is greater than p2547 – otherwise 1. Cam switching signal 2 is 0 if the actual position is greater than p2548 – otherwise 1. This means that the signal is deleted if the drive is located behind (after) the cam switching position. The position controller initiates these signals.

Direct output 1 (r2683.10)
Direct output 2 (r2683.11)

If a digital output is parameterized, the function "direct output 1" or "direct output 2", then it can be set by a corresponding command in the traversing task (SET_O) or reset (RESET_O).

Following error in tolerance (r2684.8)

When the axis is traversed, closed-loop position controlled, using a model, the permissible following error is determined from the instantaneous velocity and the selected Kv factor. Parameter p2546 defines a dynamic following error window that defines the permissible deviation from the calculated value. The status signal indicates as to whether the following error is within the window (status 1).

Target position reached (r2684.10)

The status signal "target position reached" indicates that the drive has reached its target position at the end of a traversing command. This signal is set as soon as the actual drive position is within the positioning window p2544 and is reset, if it leaves this window.

The status signal is not set, if

- Signal level 1 at binector input p2554 "signal traversing command active".
- Signal level 0 at binector input p2551 "signal setpoint static".

The status signal remains set, until

- Signal level 1 at binector input p2551 "signal setpoint static".

Reference point set (r2684.11)

The signal is set as soon as referencing has been successfully completed. It is deleted as soon as no reference is there or at the start of the reference point approach.

Acknowledgement, traversing block activated (r2684.12)

A positive edge is used to acknowledge that in the mode "traversing blocks" a new traversing task or setpoint was transferred (the same signal level as binector input p2631 activate traversing task). In the mode "direct setpoint input / MDI for setting-up/positioning" a positive edge is used to acknowledge that a new traversing task or setpoint was transferred (the same signal level as binector input p2650 "edge setpoint transfer", if the transfer type was selected using a signal edge (binector input p2649 "0" signal)).

Velocity limiting active (r2683.1)

If the actual setpoint velocity exceeds the maximum velocity p2571 – taking into account the velocity override – it is limited and the control signal is set.

4.25 Bypass (vector)

Features

- Available for the vector mode
- Available for induction motors without encoder

Description

The bypass function controls two contactors via digital outputs of the drive converter and evaluates the feedback signals of the contactors via digital inputs (e.g. via TM31). This circuit allows the motor to either be fed from the drive converter or connected directly to the supply line. The drive converter controls the contactors; the feedback signals for the contactor states must be fed back to the drive converter.

This bypass circuit can be implemented in two ways:

- Without synchronizing the motor to the line supply and
- Synchronizing the motor to the line supply.

For all bypass versions, the following applies:

- The bypass is always switched-out when one of the control word signals "OFF2" or "OFF3" is withdrawn.
- Exception:
When required, the bypass switch can be interlocked by a higher-level control so that the drive converter can be completely powered-down (i.e. including the control electronics) while the motor is operated from the line supply. The contactor interlocking should be implemented on the plant/system side.
- When the drive converter restarts after POWER OFF, the state of the bypass contactors is evaluated. This means that after running-up, the drive converter can directly change into the standby mode. This is only possible if the bypass is activated using a control signal (p1267.0 = 1, p1267.1 = 0, p1267.2 = 0) and the control signal (p1266) is still present after the drive has ramped-up.
- A changeover of the drive converter into the standby mode after the drive has ramped-up has a higher priority than the automatic restart.
- The motor temperatures are monitored using temperature sensors while the drive converter is only of the two standby modes.
- The two motor contactors must be designed for switching under load.

Requirements

The bypass function is only possible for sensorless close-loop speed control (p1300 = 20) or V/f control (p1300 = 0...19) and when an induction motor is used. A VSM10 must be used for synchronizing with overlap.

Commissioning the bypass function

The bypass function is part of the function module “technology controller” that can be activated when using the commissioning Wizards. Parameter r0108.16 indicates whether it has been activated.

4.25.1 Bypass with synchronization with overlap (p1260 = 1)

Description

When “bypass with synchronization with overlap (p1260 = 1)” is activated, then motor is transferred, synchronized to the line supply and is also retrieved again. During the changeover, the two contactors K1 and K2 are simultaneously closed for a time (phase lock synchronization).

A reactor is used to de-couple the drive converter from the line supply – the uk value for the reactor is 10 % +/- 2 %.

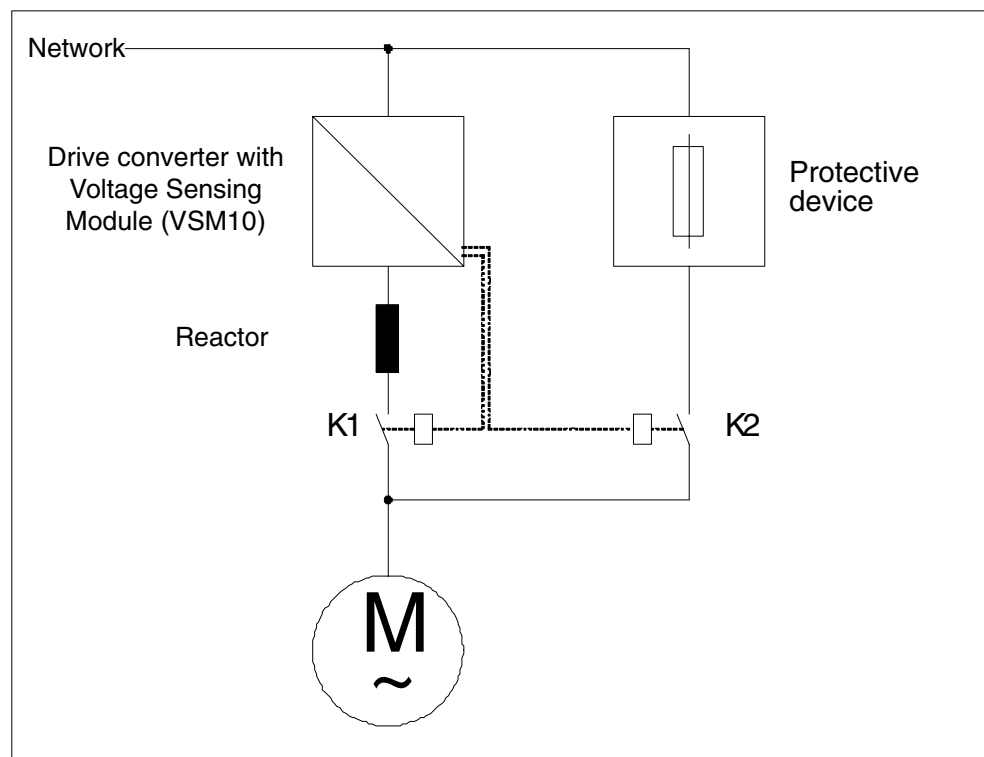


Fig. 4-30 Circuit example: Bypass with synchronization with overlap

Activation

The bypass function with synchronization with overlap (p1260 = 1) can only be activated using a control signal (p1267.0 = 1, p1267.1 = 0, p1267.2 = 0); it is not possible to activate this function using a speed threshold or a fault.

Example

The following parameters must be set after the bypass function with synchronization with overlap (p1260 = 1) has been activated.

Table 4-9 Parameter setting for the bypass function with synchronization with overlap

Parameter	Description
p1266 =	Setting of the control signal for p1267.0 = 1
p1267.0 = 1 p1267.1 = 0 p1267.2 = 0	Bypass function is initiated by the control signal
p1269[0] =	Signal source to provide the feedback signal of contactor K1
p1269[1] =	Signal source to provide the feedback signal of contactor K2
p3800 = 1	The internal voltages are used for synchronization
p3802 = r1261.2	Synchronization is activated by the bypass function

Transfer operation

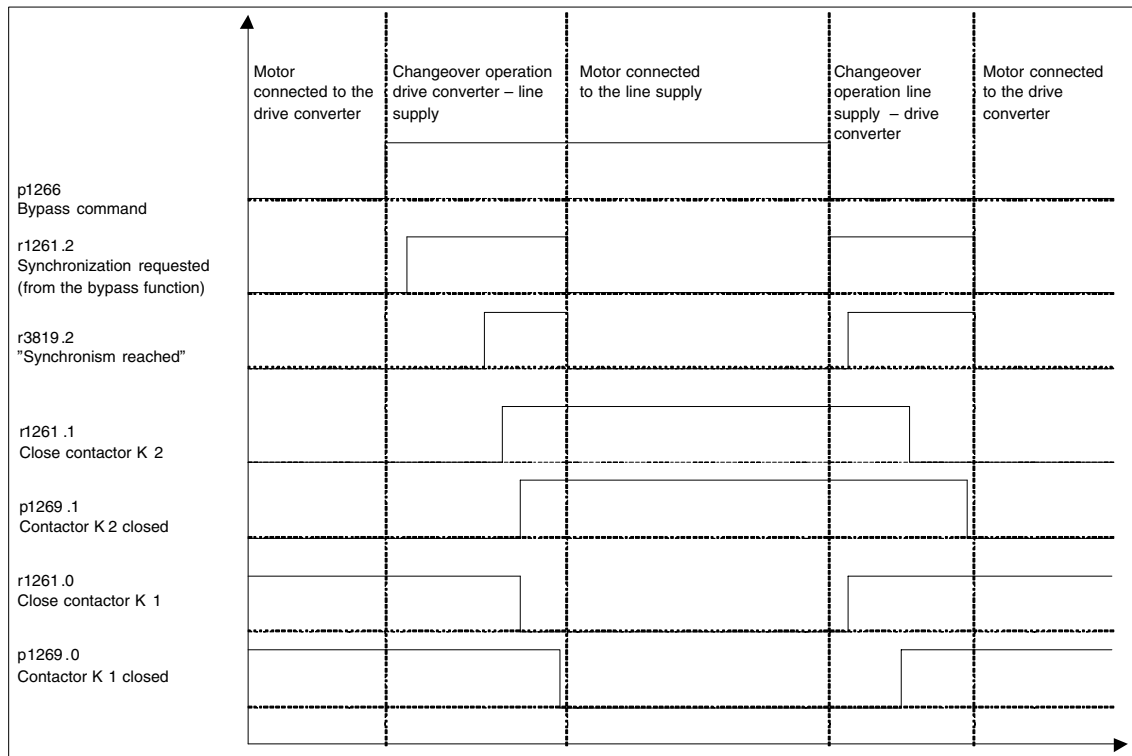


Fig. 4-31 Signal diagram, bypass with synchronization with overlap

The motor is transferred to the line supply
(the drive converter controls contactors K1 and K2):

- The initial state is as follows: Contactor K1 is closed, contactor K2 is open and the motor is fed from the drive converter.
- The control bit “bypass command” (p1266) is set (e.g. from the higher-level automation).
- The bypass function sets the control word bit “synchronizing” (r1261.2).
- The bit is set which means that while the drive converter is operational, the synchronizing operation “transfer the motor to the line supply” is initiated.
- After the motor has been synchronized to the line supply frequency, voltage and phase position, the synchronization algorithm signals this state (r3819.2).
- The bypass mechanism evaluates this signal and closes contactor K2 (r1261.1 = 1). The signal is internally evaluated – BICO wiring is not required.
- After contactor K2 has signaled back the “closed” state (r1269[1] = 1), contactor K1 is opened and the drive converter inhibits the pulses. The drive converter is in the “hot standby” state.
- If the on command is withdrawn in this phase, the drive converter changes into the basic standby state. If the appropriate contactors are being used, the drive converter is isolated from the line supply and the DC link is discharged.

The motor is changed over from line supply operation to converter operation in the inverse sequence: At the start of the operation, contactor K2 is closed and contactor K1 is opened.

- The control bit “bypass command” is deleted (e.g. from the higher-level automation).
- The bypass function sets the control word bit “synchronizing”.
- The pulses are enabled. “Synchronizing” is set before “pulse enable”. This means that the drive converter interprets this as a command to retrieve the motor from the line supply and resume operation with the motor.
- After the drive converter has synchronized to the line supply frequency, voltage and phase position, the synchronizing algorithm signals this state.
- The bypass mechanism evaluates this signal and closes contactor K1. The signal is internally evaluated – BICO wiring is not required.
- After contactor K1 signals back the “closed” state, contactor K2 is opened and the motor is again fed from the drive converter.

4.25.2 Bypass with synchronization, without overlap (p1260 = 2)

When “bypass with synchronization without overlap (p1260 = 2)” is activated, contactor K2 to be closed is first closed when contactor K1 has opened (anticipatory type synchronization). The motor voltage phase position before synchronization must be set so that a “lead” is obtained before the line supply to which the system must be synchronized; this is realized by setting the synchronizing setpoint (p3809). As a result of the motor braking in the short time during which, both contactors are open, when closing contactor K2, a phase and frequency difference of approximately zero is obtained.

It is no longer necessary to use the de-coupling reactor after having determined the synchronizing setpoint (p3809).

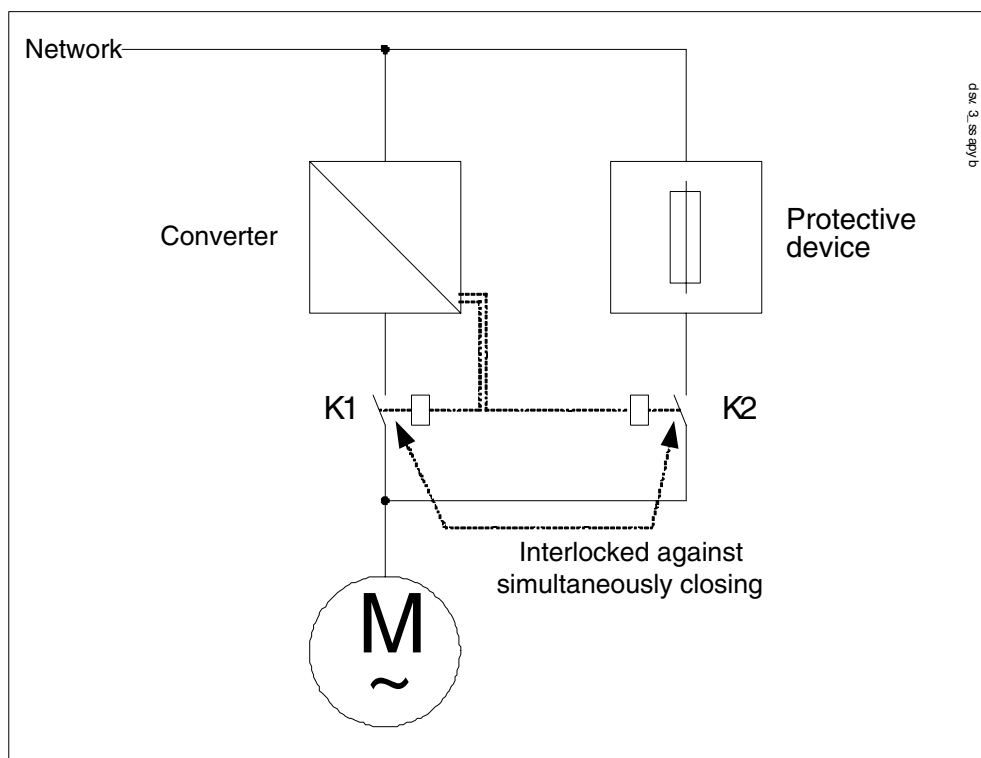


Fig. 4-32 Circuit example, bypass with synchronization without overlap

Activation

It is only possible to activate the bypass function with synchronization without overlap (p1260 = 2) using a control signal (p1267.0 = 1, p1267.1 = 0, p1267.2 = 0); it is not possible to activate this function using a speed threshold or a fault.

Example

The following parameters must be set after the bypass function with synchronization without overlap (p1260 = 2) has been activated.

Table 4-10 Parameter setting for the bypass function with synchronization without overlap

Parameter	
p1266 =	Setting of the control signal for p1267.0 = 1
p1267.0 = 1 p1267.1 = 0 p1267.2 = 0	Bypass function is initiated by the control signal
p1269[0] =	Signal source to provide the feedback signal of contactor K1
p1269[1] =	Signal source to provide the feedback signal of contactor K2
p3800 = 1	The internal voltages are used for synchronization
p3802 = r1261.2	The bypass function activates the synchronization

4.25.3 Bypass without synchronization (p1260 = 3)

Description

When the motor is transferred to the line supply, contactor K1 is opened (after the drive converter pulses have been inhibited); the system then waits for the motor de-excitation time and then contactor K2 is closed so that the motor is directly connected to the line supply.

Because the motor is not synchronized when it is connected to the line supply an equalization current flows. This must be taken into account when designing the protective equipment (refer to Fig. 4-33).

When the converter retrieves the motor from the line supply, initially contactor K2 is opened, and after the excitation time has expired, contactor K1 is closed. The drive converter then connects to the rotating motor and the motor is fed from the drive converter.

In this case, contactor K2 must be designed/selected to be able to switch inductive loads. Contactors K1 and K2 must be interlocked so that they cannot simultaneously close.

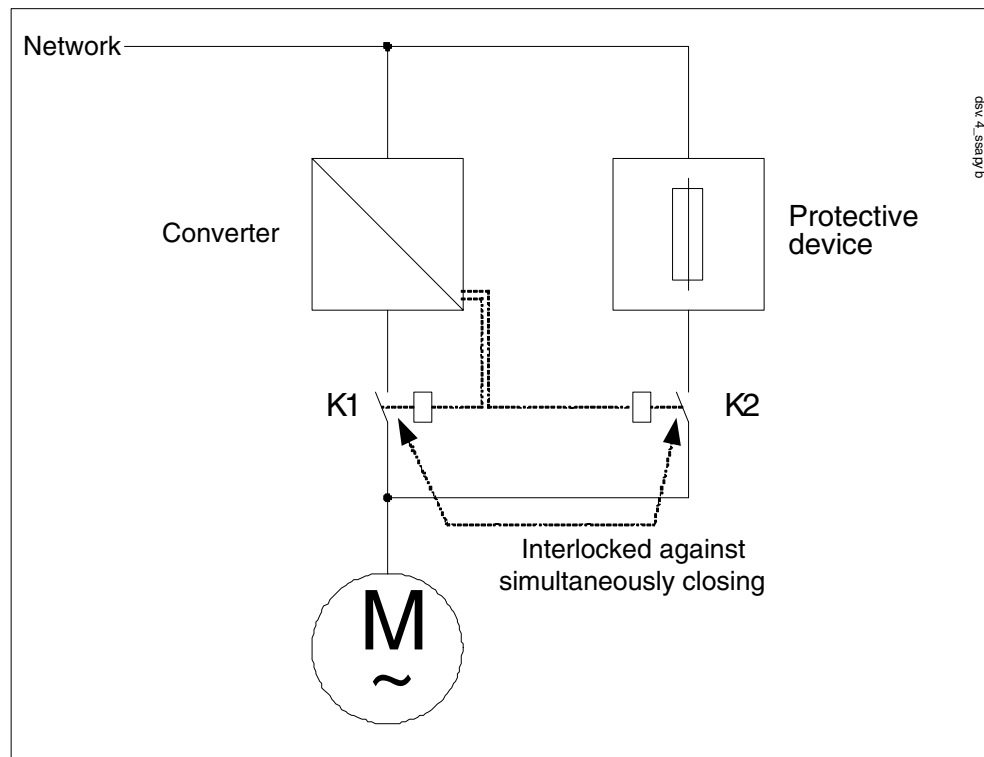


Fig. 4-33 Circuit example, bypass without synchronization

Activation

The bypass without synchronization (p1260 = 3) can be activated using the following signals (p1267):

- Bypass using the control signal (p1267.0 = 1):

The bypass is switched-in using a digital signal (p1266), e.g. from a higher-level automation system. If the digital signal is withdrawn again after the debypass delay time has expired (p1263), then a changeover is made to drive converter operation.

- Bypass for speed threshold (p1267.1 = 1):

When a specific speed is reached, a changeover is made to bypass; this means that the drive converter is used as starting converter. The prerequisite for switching-in the bypass is that the speed setpoint is greater than the bypass speed threshold (p1265).

Converter operation is re-selected when the setpoint (at the input of the ramp-function generator, r1119) drops below the bypass speed threshold (p1265). As a result of the condition – setpoint > comparison value, it is prevented that the bypass is immediately re-activated if, after switching back to converter operation, the actual speed is still above the bypass speed threshold (p1265).

- Bypass for a fault condition (p1267.2 = 1):

The motor is used as “reserve” for direct online operation if the drive converter fails. After the fault has been successfully acknowledged, and if the drive converter on command is still present after the debypass delay time (p1263) has expired, then it is automatically re-started and changed over to drive converter operation.

Note

Selecting the activation “bypass for a fault condition” and the automatic restart function can potentially influence one another. The fault that switches-in the bypass is acknowledged when the automatic restart function is appropriately set and when the fault is successfully acknowledged, the bypass is switched-out again. There is no mutual interlocking of these two functions.

Parameters are used to set the quantities – bypass time, debypass time, bypass speed and the command source for the changeover.

The following signal diagram shows the timing when the bypass switch is on when activating “bypass for fault”.

Example

After activating the bypass function without synchronization (p1260 = 3) the following parameters still have to be set:

Table 4-11 Parameter setting for the bypass function with synchronization with overlap

Parameter	Description
p1262 =	Setting the bypass deadtime
p1263 =	Setting the debypass deadtime
p1264 =	Setting the bypass delay time
p1265 =	Setting of the speed threshold for p1267.1 = 1
p1266 =	Setting of the control signal for p1267.0 = 1
p1267.0 = p1267.1 = p1267.2 =	Setting the trigger signal for the bypass function
p1269[0] =	Signal source to provide the feedback signal of contactor K1
p1269[1] =	Signal source to provide the feedback signal of contactor K2
p3800 = 1	The internal voltages are used for synchronization
p3802 = r1261.2	Synchronization is activated by the bypass function

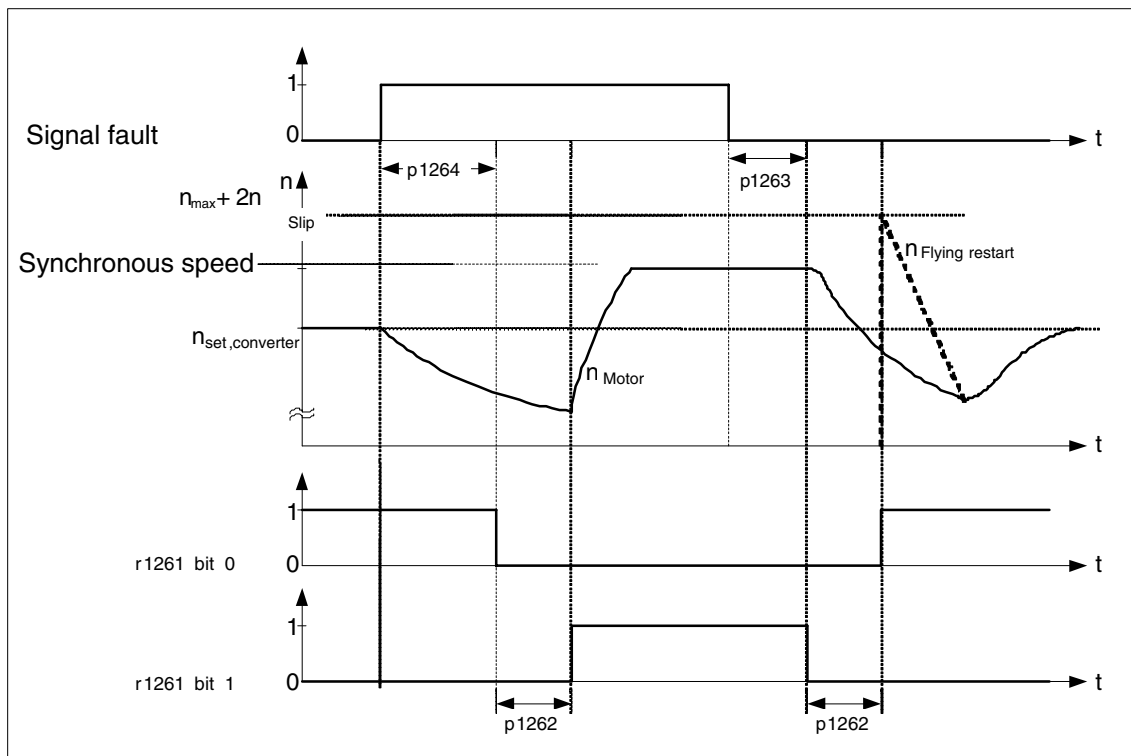


Fig. 4-34 Signal diagram, bypass without synchronization, selection "bypass for fault"

When the drive converter fault occurs, the drive initially responds by inhibiting the pulses; changeover is initiated after the bypass time ($p1264$) has expired: Contactor K1 is opened ($r1261.0 = 0$) and the system waits for the bypass deadtime to expire ($p1262$ – this must correspond to at least the motor de-excitation time). Contactor K2 is then closed ($r1261.1 = 1$) which means that the motor is directly connected to the line supply.

After the fault is no longer present, the system waits for the debypass time time ($p1263$), and then the drive converter can again feed the motor. To do this, contactor K2 is opened ($r1261.1 = 0$) and after the bypass deadtime ($p1262$), contactor K1 is closed ($r1261.0 = 1$). The converter is connected to the motor – that is generally still rotating – and normal operation is resumed.

Overview of important parameters (refer to the List Manual)

Bypass function

- p1260 Bypass configuration
- r1261 CO/BO: CO/BO: Bypass control/status word
- p1262 Bypass deadtime
- p1263 Debypass delay time
- p1264 Bypass delay time
- p1265 Bypass speed threshold
- p1266 BI: BI: Bypass control signal
- p1267 Bypass source configuration
- p1268 BI: Bypass control signal
- p1269 BI: Bypass switch, feedback signal, signal source

Synchronization

- p3800 Sync line-drive activation
- p3801 Sync line-drive object number
- p3802 BI: Sync line-drive enable
- r3803 CO/BO: Sync line-drive control word
- r3804 CO: Sync line-drive target frequency
- r3805 CO: Sync line-drive frequency difference
- p3806 Sync line-drive frequency difference threshold value
- r3808 CO: Sync line-drive phase difference
- p3809 Sync line-drive phase setpoint
- p3811 Sync line-drive frequency limiting
- r3812 CO: Sync line-drive correction frequency
- p3813 Sync line-drive phase synchronism, threshold value
- r3814 CO: Sync line-drive voltage difference
- p3815 Sync line-drive voltage difference, threshold value
- p3816 CI: Sync line-drive voltage actual value $U_{12} = U_1 - U_2$
- p3817 CI: Sync line-drive voltage actual value $U_{23} = U_2 - U_3$
- r3819 CO/BO: Sync line-drive status word

Function diagram (refer to the List Manual)

- 7020 Synchronization

4.26 Synchronization (vector)

Features

- For the vector mode
- For induction motors without encoder
- Line supply sensing using the Voltage Sensing Module (VSM10) connected to the infeed or vector (p3801)
- Connector inputs for the actual voltage sensing of the motor via VSM10 (p3816, p3817)
- Setting a phase difference (p3809)
- Can be activated by parameter (p3802)

Description

Using the synchronizing function, it is possible to synchronize to the line supply, for example, in order to directly transfer to the line supply after synchronization (bypass). An additional application is to temporarily operate the motor from the line supply in order to be able to carry out maintenance work on the drive converter without incurring any down times.

Synchronizing is activated using parameter p3800 and either internal or external actual voltage sensing is selected. For the internal actual voltage sensing (p3800 = 1), the voltage setpoints of the electrical motor model are used for synchronizing. For the external actual voltage sensing (p3800 = 2), the voltage is sensed using a VSM, this is connected between the Motor Module and Motor. The voltage values must be transferred to the synchronization via connectors p3816 and p3817.

Prerequisite

- Firmware release 2.4
- Drive object, vector/infeed with connected VSM10
- Induction motor without encoder
- Vector control

Overview of important parameters (refer to the List Manual)

- p3800 Sync line-drive activation
- p3801 Sync line-drive object number
- p3802 BI: Sync line-drive enable
- r3803 CO/BO: Sync line-drive control word
- r3804 CO: Sync line-drive target frequency
- r3805 CO: Sync line-drive frequency difference
- r3819 CO/BO: Status word, synchronizing

Function diagram (refer to the List Manual)

- 7020 Synchronization

4.27 Terminal Module 41 (TM41)

Features

- General
 - Pulse encoder emulation, TTL signals (RS422)
 - Max. encoder output frequency 256 kHz (e.g. 1500 RPM at 8192 pulses)
 - 1 analog input
 - 4 digital inputs
 - 4 bidirectional digital inputs/outputs
- Pulse encoder emulation of a speed value and generation of a position value (p4400 = 0)
 - PROFIdrive telegram 3
 - Own control word (r0898)
 - Own status word (r0899)
 - Sequence control (refer to function diagram 9682)
 - Settable pulse number (p0408)
 - Enable zero marks (p4401.0)
 - Settable zero mark position (p4426)
 - Operating display (r0002)
- Pulse encoder emulation of an encoder position actual value (p4400 = 1)
 - Input for incremental signals (p4420)
 - Deadtime compensation (p4421)
 - For one zero mark
 - For one Encoder Data Set (EDS)
 - Settable pulse number (p0408)
 - Enable zero marks (p4401.0)
 - Settable zero mark position for encoder position actual value from an absolute encoder (p4426)
 - Resolvers are not supported

General description

The TM41 outputs incremental encoder signals. The signals can be generated using a speed value via a process data word (p4400 = 0) or using an encoder position actual value of a drive (p4400 = 1). The incremental encoder signal can, for example, be evaluated by a control or other drives.

One analog input, 4 digital inputs and 4 bidirectional digital inputs/outputs are available. The can, for example, be used to enter an analog speed setpoint and transfer control and status signals – e.g. OFF1/ON, ready or fault.

Description (p4400 = 0) incremental encoder emulation using a speed value

Example:

A speed setpoint is received via PROFIdrive telegram 3 (r2060), which is interconnected to p1155. The speed setpoint can be filtered using a (p1414.0) PT2 element (p1417 and p1418) and delayed with a deadtime (p1412). The number of encoder pulses per revolution can be set using parameter p0408. The distance between the zero marks and the position when enabling the A/B tracks (r4402.1) can be entered into parameter p4426 and enabled with p4401.0.

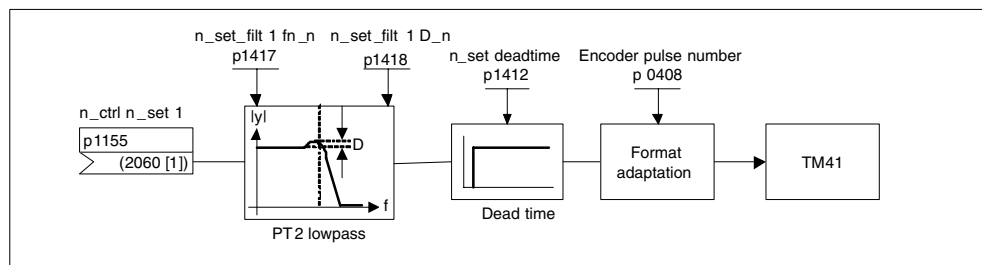


Fig. 4-35 Block diagram of the incremental encoder emulation

Description (p4400 = 1) incremental encoder emulation using encoder position actual value

The encoder position actual value of a drive (r0479) is interconnected to the TM41 via a connector input (p4420) and is therefore available at the TM41 as pulse encoder emulation. The signals of the pulse encoder emulation can, for example, be read-in from one control. This means, for example, it is possible to implement a position controller in the control and to transfer its output as analog speed setpoint to the drive. The number of encoder pulses per revolution (p0408) and the fine interpolation (p0418) must be set the same as the drive. The sampling time p4099[3] must be set to the current controller clock cycle (p0115[0]) of the drive. The runtime of the encoder position actual value up to the pulse encoder emulation can be compensated using the deadtime compensation with p4421. If p4422 = 1, the input signal p4420 is inverted.

Example, commissioning the incremental encoder emulation using the encoder position actual value (p4400 = 1)

Encoder signals from the motor encoder should be output from the SERVO drive object via TM41.

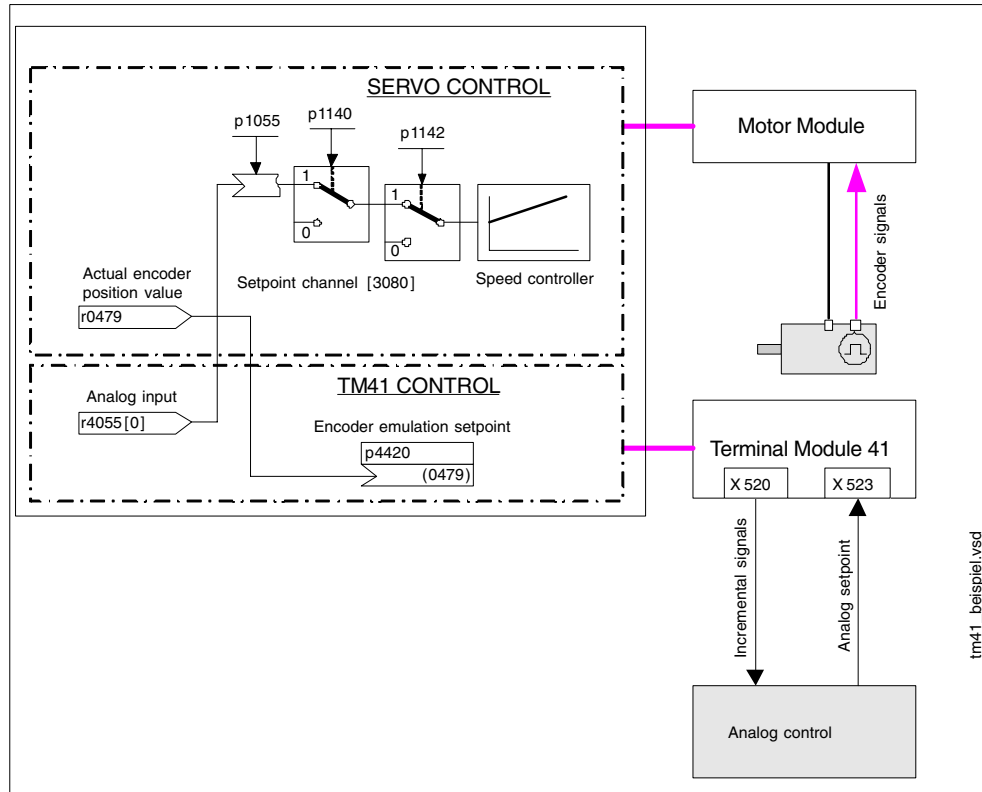


Fig. 4-36 Example, TM41

- p4400 = 1
- p4420 = r0479[0] (SERVO)
- p0010 = 4
- p0408 = pulse number of the motor encoder from SERVO
- p0418 = fine resolution of the motor encoder from SERVO
- p0010 = 0
- p4099[3] = current controller clock cycle from SERVO (p0115[0])
- Copying from RAM to ROM
- Power on reset

Conditions

- Firmware release 2.4
- Terminal Module 41 (TM41)

Overview of important parameters (refer to the List Manual)

General:

- r0002 TM41 operating display
- p0408 Rotary encoder pulse number
- p0418 Fine resolution Gx_XIST1 (in bits)
- p4400 Incremental encoder emulation TM41 operating mode
- p4401 Incremental encoder emulation TM41 mode
- p4402 Incremental encoder emulation status
- p4422 TM41 position actual value inversion
- p4426 Incremental encoder emulation, pulses for zero mark

Incremental encoder emulation using a speed setpoint (p4400 = 0)

- p0840 BI: ON/OFF1
- r0898 CO/BO: Control word sequence control
- r0899 CO/BO: Status word sequence control
- p1155 CI: Incremental encoder emulation speed setpoint 1

Incremental encoder emulation using a position setpoint (p4400 = 1)

- p4420 CI: Incremental encoder emulation, encoder position actual value
- p4421 Incremental encoder emulation, deadtime compensation

Function diagrams (refer to the List Manual)

- 9660 Digital inputs, electrically isolated (DI 0 ... DI 3)
- 9661 Digital inputs/outputs, bi-directional (DI/DO 0 and DI/DO 1)
- 9662 Digital inputs/outputs, bi-directional (DI/DO 2 and DI/DO 3)
- 9674 Incremental encoder emulation (p4400 = 0)
- 9676 Incremental encoder emulation (p4400 = 1)
- 9682 Sequence control

4.28 Changing over units

Description

By changing over the units, parameters and process quantities for input and output can be changed over to an appropriate system of units (US units or as per unit quantities (%)).

The following supplementary conditions apply when changing over units:

- Parameters of the type plate of the drive converter or the motor rating plate can be changed over between SI/US units; however, a per unit representation is not possible.
- After changing over the units parameter, all parameters that are assigned to one of the units group dependent on it, are all changed over to the new system of units.
- A parameter is available to select technological units (p0595) to represent technological quantities in the technology controller.
- If the units are changed over to per unit quantities and the reference quantity changed, then the percentage value entered in a parameter is not changed.

Example:

- A fixed speed of 80 % corresponds, for a reference speed of 1500 RPM, to a value of 1200 RPM.
- If the reference speed is changed to 3000 RPM, then the value of 80 % is kept and now means 2400 RPM.

Groups of units

Every parameter that can be changed over is assigned to a units group, that, depending on the group, can be changed over within certain limits.

This assignment for each parameter can be seen in the parameter list in the List Manual.

Table 4-12 Groups of units: Changeover using p0100, can be changed over for p0010 = 1

Changeover group	Units for p0100 =		Reference quantity for %
	0	1	
14_2	W	HP	–
14_6	kW	HP	–

Changing over units

Table 4-13 Groups of units: Changeover using p0349, can be changed over for p0010 = 5

Changeover group	Units for p0349=		Reference quantity for %
	1	2	
15_1	mH	%	$\frac{1000 \times p0304}{2 \times \pi \times \sqrt{3} \times p0305 \times p0310}$
16_1	Ohm	%	$\frac{p0304}{\sqrt{3} \times p0305}$

Table 4-14 Groups of units: Changeover using p0505, can be changed over for p0010 = 5

Changeover group	Units for p0505=				Reference quantity for %
	1	2	3	4	
2_1	Hz	%	Hz	%	p2000
2_2	kHz	%	kHz	%	p2000
3_1	RPM	%	RPM	%	p2000
5_1	V	%	V	%	p2001
6_1	mA	%	mA	%	p2002
6_2	O	%	O	%	p2002
7_1	Nm	%	lbf*ft	%	p2003
7_2	Nm	Nm	lbf*ft	lbf*ft	p2003
14_1	W	%	HP	%	r2004
14_5	kW	%	HP	%	r2004
17_1	Nms/rad	%	lbf*ft*s/rad	%	p2003/p2000
18_1	V/A	%	V/A	%	p2001/p2002
19_1	A/V	%	A/V	%	p2002/p2001
21_1	°C	°C	°F	°F	–
21_2	K	K	°F	°F	–
22_1	m/s ²	m/s ²	ft/s ²	ft/s ²	–
23_1	Vs/m	Vs/m	Vs/ft	Vs/ft	–
25_1	kgm ²	kgm ²	lbf ²	lbf ²	–
26_1	m/s ³	m/s ³	ft/s ³	ft/s ³	–
27_1	kg	kg	lb	lb	–
28_1	Nm/A	Nm/A	lbf*ft/A	lbf*ft/A	–

Overview of important parameters (refer to the List Manual)

- p0100 Motor Standard IEC/NEMA
- p0349 Selecting the system of units, motor equivalent circuit diagram data
- p0505 Selecting the system of units
- p0595 Selecting technological units
- p0596 Reference quantity, technological units

4.29 Application examples with the DMC20

4.29.1 Features

The DRIVE-CLiQ Hub Module Cabinet 20 (DMC20) has the following features:

- Own drive object
- 6 DRIVE-CLiQ ports
- Own faults and alarms

Typical applications would include:

- Implementation of a distributed topology via a DRIVE-CLiQ cable
- Hot plugging (a DQ connection is withdrawn in operation)

4.29.2 Description

The DRIVE-CLiQ Hub Module Cabinet 20 (DMC20) is used for the star-shaped distribution of a DRIVE-CLiQ line. With the DMC20, an axis grouping can be expanded with four DRIVE-CLiQ sockets for additional subgroups.

The component is especially suitable for applications which require DRIVE-CLiQ nodes to be removed in groups, without interrupting the DRIVE-CLiQ line and therefore the data exchange.

4.29.3 Example, distributed topology

Description

Several direct length measuring systems are used in a machine. These are to be combined in an electrical cabinet and connected to the Control Unit via a DRIVE-CLiQ cable.

When using a DMS20, up to five measuring systems can be combined. The measuring systems are not directly assigned the drive objects and these must be assigned in the topology view of STARTER (also refer to the Commissioning Manual, Chapter “Changing the offline topology in STARTER”).

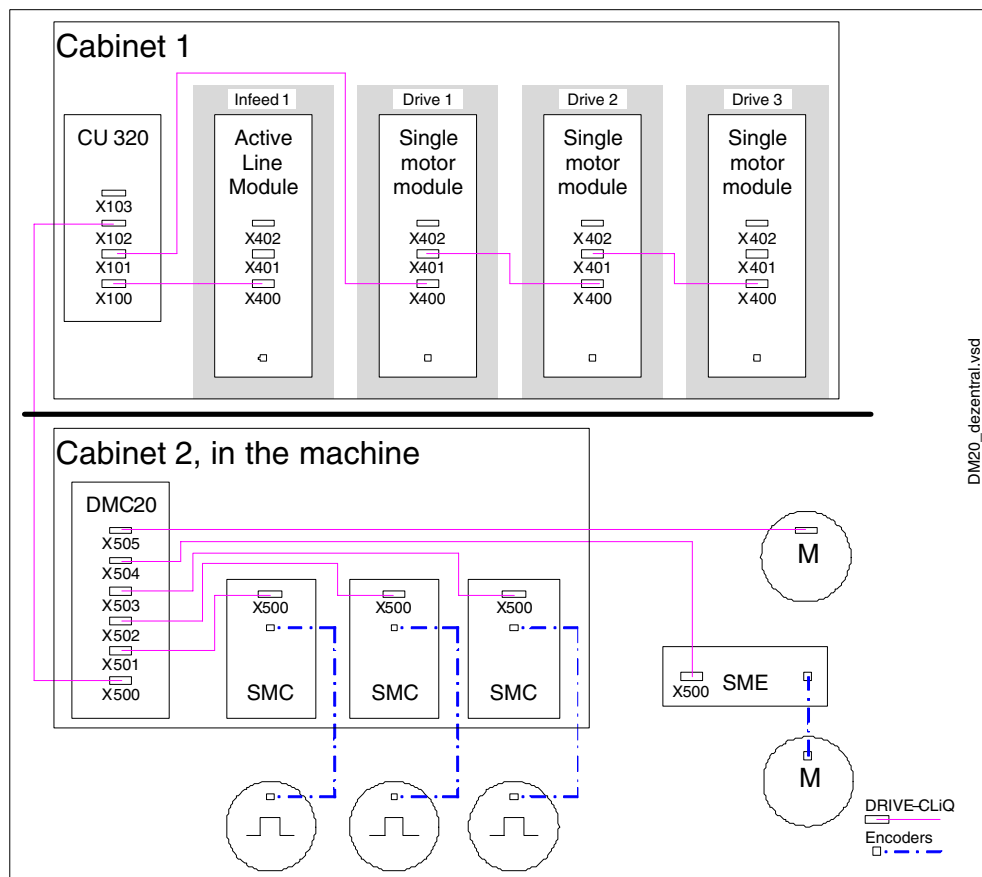


Fig. 4-37 Example, distributed topology using DMC20

4.29.4 Example, hot plugging

Description

Using the hot-plugging function, components can be withdrawn from the operational drive line-up (the other components continue to operate) on the DRIVE-CLiQ line. This means that the corresponding drive object must first be de-activated/parked beforehand using parameter p0105 or STW2.7 (also refer to 4.12 and 4.13).

The following prerequisites must be fulfilled:

- Hot plugging is only possible when a drive object is connected in a star configuration to a Control Unit or to the DRIVE-CLiQ Hub DMC20. The system does not support removing DRIVE-CLiQ connections between the other DRIVE-CLiQ components e.g. Sensor/Terminal Module to the Motor Module, Motor Module to the Motor Module.
- De-activating the complete drive object using p0105 or STW2.7. In so doing, all of the components, that are assigned to the drive object (e.g. Motion Modules and Sensor Modules) are deactivated.

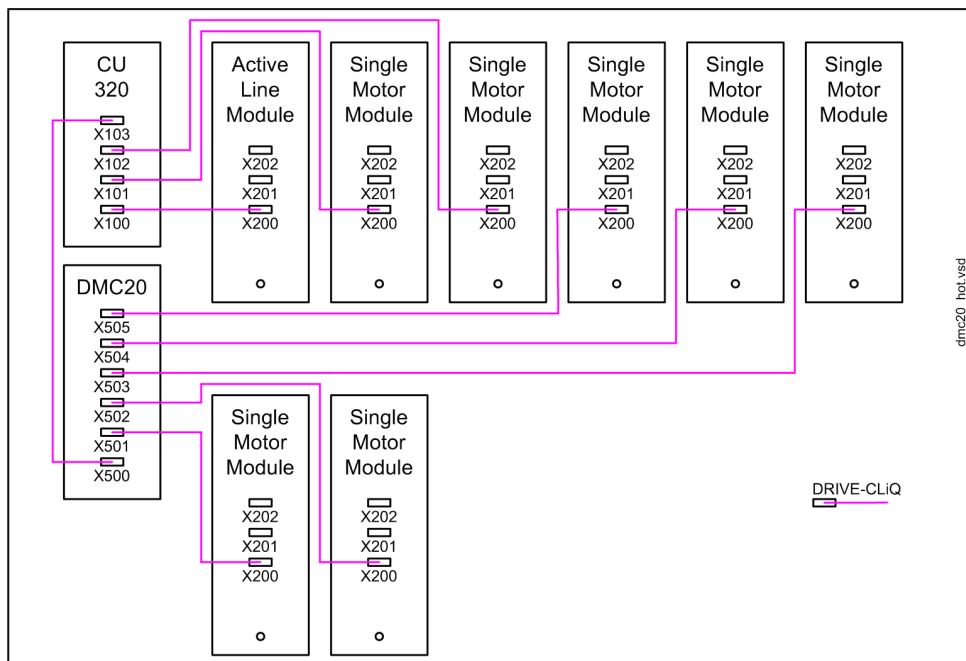


Fig. 4-38 Example of a hot plugging topology

Note

In order to disconnect and isolate the power unit from the DC link, additional measures must be applied – such as DC link wiring through the DC link infeed adapter and DC link disconnecting devices. The safety information and instructions in the Equipment Manual must be carefully observed.

4.29.5 Overview of important parameters (refer to the List Manual)

- p0105 Activate/deactivate drive object
- r0106 Drive object active/inactive
- p0897 BI: Parking axis selection
- r0896.0 BO: Parking axis status word
- p0151 DRIVE-CLiQ Hub component number
- p0154 DRIVE-CLiQ Hub identification using LED
- p0157 DRIVE-CLiQ Hub EPROM data version
- r0158 DRIVE-CLiQ Hub firmware version

4.30 Position tracking/measuring gearbox

4.30.1 Description

If there is a mechanical gearbox (measuring gearbox) located between an endlessly rotating motor/load and the encoder and the position control is to be realized using this absolute encoder, then depending on the gearbox ratio, at each encoder overflow, an offset occurs between the zero position of the encoder and the motor/load.

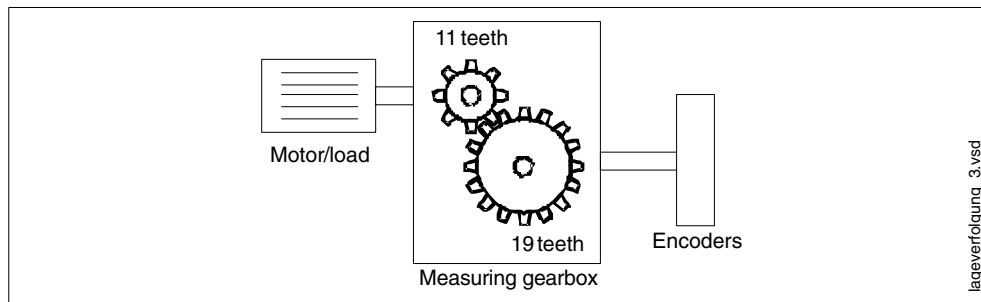


Fig. 4-39 Position tracking

In order to determine the position at the motor/load, in addition to the position actual value of the absolute encoder, it is also necessary to have the number of overflows of the absolute encoder.

If the power supply of the control module must be powered-down, then the number of overflows must be saved in a non-volatile memory so that after powering-up the position of the load can be uniquely and clearly determined.

Example: Gearbox ratio 1:3, absolute encoder can count 8 revolutions

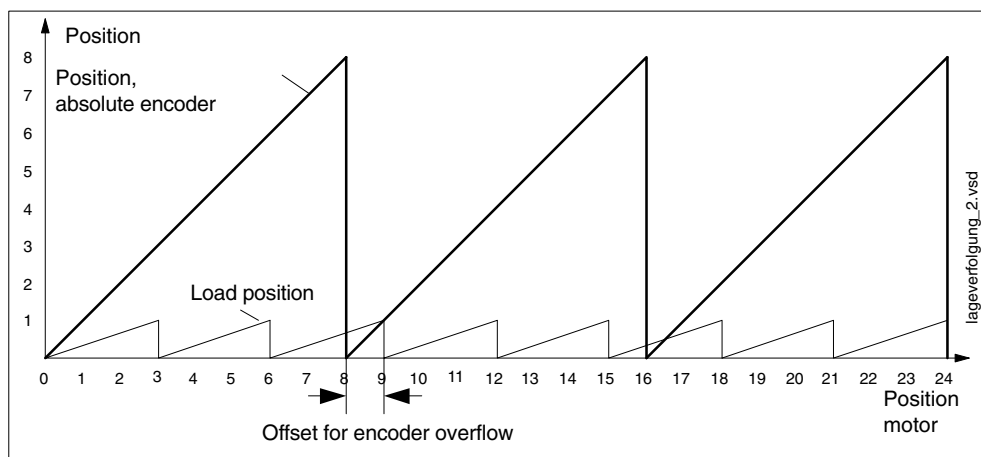


Fig. 4-40 Drive with an uneven gearbox and modulo axis

In this case, for each encoder overflow, there is a load-side offset of 1/3 of a load revolution, after 3 encoder overflows, the motor and load zero position coincide again. The position of the load can no longer be clearly reproduced after one encoder overflow.

Note

The ratio stamped on the gearbox type plate is often just a rounded-off value (e.g. 1:7.34). If, for a rotary axis, it is not permissible to have any long-term drift, then the actual ratio of the gearbox teeth must be requested from the gearbox manufacturer.

Notice

The position can only be reproduced if, in the powered-down state, if the encoder was moved through less than half of the range that it can represent. For the standard EQN1325 encoder, this is 2048 revolutions or half a revolution for single-turn encoders.

Note regarding using synchronous motors with a measuring gearbox

Field-oriented control of synchronous motors requires a clear reference between the pole position and encoder position. This reference must also be carefully maintained when using measuring gearboxes: This is the reason that the ratio between the pole pair number and the encoder revolutions must be an integer multiple ≥ 1 (e.g. pole pair number 17, measuring gearbox 4.25, ratio = 4).

4.30.2 Prerequisites

- Absolute encoder
- Firmware release ≥ 2.4
- CU320 with Order No. 6SL3040-- 0AA1 and Version C or higher

4.30.3 Integration

The position tracking and measuring gearbox functions are integrated as follows in the system.

Overview of important parameters (refer to the List Manual)

- p0402 Gearbox type selection
- p0411 Measuring gearbox configuration
- p0413 Measuring gearbox position tracking, tolerance window
- p0432 Gearbox factor, numerator value
- p0433 Gearbox factor, denominator value

Function diagrams

- 4704 Position and temperature sensing, encoders 1 ... 3
- 4710 Speed actual value and pole position sensing, motor encoder (encoder 1)
- 6010 Speed actual value and pole position sensing, motor encoder (encoder 1)



Basic Information about the Drive System

5

5.1 Parameter

Parameter types

The following adjustable and visualization parameters are available:

- Adjustable parameters (read/write)

These parameters have a direct impact on the behavior of a function.

Example: Ramp-up and ramp-down time of a ramp-function generator

- Visualization parameters (read only)

These parameters are used to display internal variables.

Example: Current motor current

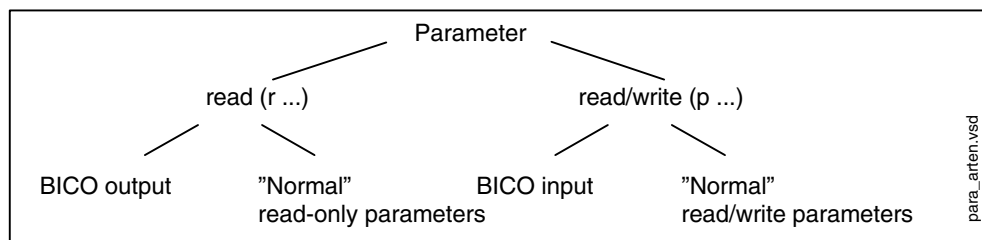


Fig. 5-1 Parameter types

Parameter categories

The parameters for the individual drive objects (see 5.3) are categorized according to data sets as follows (see 5.2):

- Data-set-independent parameters

These parameters exist only once per drive object.

- Data-set-dependent parameters

These parameters can exist several times for each drive object and can be addressed via the parameter index for reading and writing. A distinction is made between various types of data set:

- CDS: Command Data Set (refer to Section 5.2)

By parameterizing several command data sets and switching between them, the drive can be operated with different pre-configured signal sources.

- DDS: Drive Data Set

The drive data set contains the parameters for switching between different drive control configurations.

The CDS and DDS can be switched over during normal operation. Further types of data set also exist, however these can only be activated indirectly by means of a DDS switchover.

- EDS Encoder Data Set
- MDS Motor Data Set

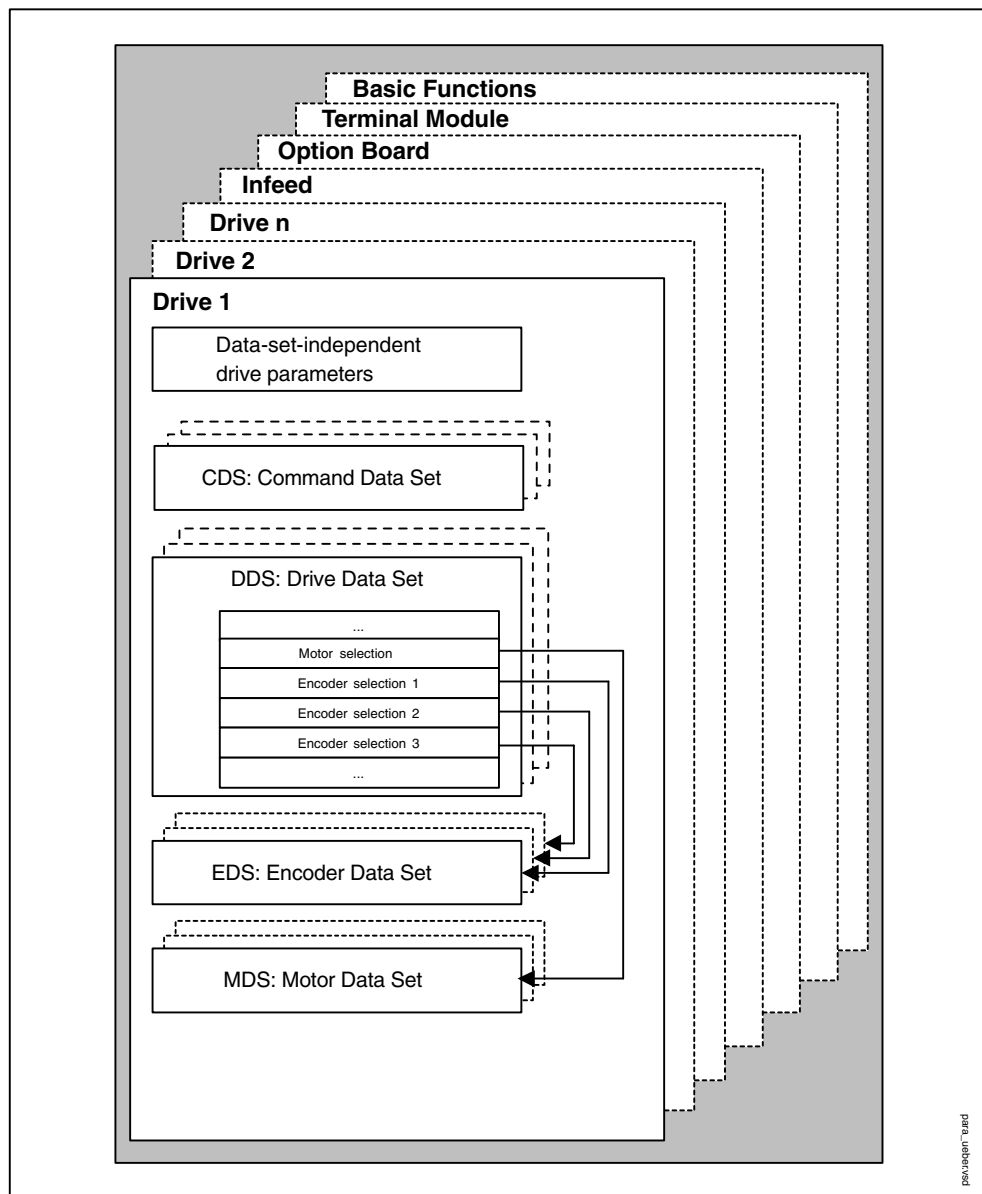


Fig. 5-2 Parameter categories

Saving parameters in a non-volatile memory

The modified parameter values are stored in the volatile RAM. When the drive system is switched off, this data is lost.

The data has to be saved as follows in a non-volatile memory so that it is available the next time the drive is switched on.

- Save parameters – device and all drives
p0977 = 1 Is automatically reset to 0
- Save the parameters with STARTER
See “Copy RAM to ROM” function

Resetting parameters

The parameters can be reset to the factory setting as follows:

- Reset parameters – current drive object
p0970 = 1 Is automatically reset to 0
- Reset parameters – All parameters drive object “Control Unit”
p0009 = 30 Parameter reset
p0976 = 1 Is automatically reset to 0

5.2 Data sets

CDS: Command Data Set

The BICO parameters (binector and connector inputs) are grouped together in a command data set. These parameters are used to interconnect the signal sources of a drive (see Section 5.4).

By parameterizing several command data sets and switching between them, the drive can be operated with different pre-configured signal sources.

A command data set contains the following (examples):

- Binector inputs for control commands (digital signals)
 - ON/OFF, enable signals (p0844, etc.)
 - Jog (p1055, etc.)
- Connector inputs for setpoints (analog signals)
 - Voltage setpoint for V/f control (p1330)
 - Torque limits and scaling factors (p1522, p1523, p1528, p1529)

One command data set is available for servo mode and two for vector mode.

The following parameters are available for selecting command data sets and for displaying the currently selected command data set in vector mode:

Table 5-1 Command data set: selection and display

CDS	Selection	Display	
	Bit 0 p0810	Selected r0836	Active r0050
0	0	0	0
1	1	1	1

If a command data set that does not exist is selected, the current data set remains active.

Example: Switching between command data set 0 and 1

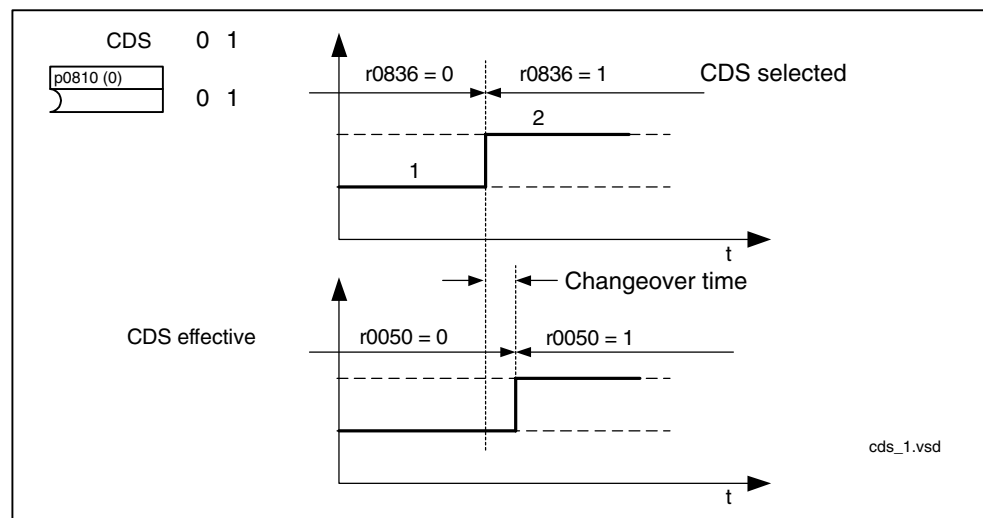


Fig. 5-3 Switching the command data set (example)

DDS: Drive Data Set

A drive data set contains various adjustable parameters that are relevant with respect to open and closed-loop drive control:

- Numbers of the assigned motor and encoder data sets:
 - p0186: assigned motor data set (MDS)
 - p0187 to p0189: up to 3 assigned encoder data sets (EDS)
- Various control parameters, e.g.:
 - Fixed speed setpoints (p1001 to p1015)
 - Speed limits min./max. (p1080, p1082)
 - Characteristic data of ramp-function generator (p1120 ff)
 - Characteristic data of controller (p1240 ff)
 - ...

The parameters that are grouped together in the drive data set are identified in the SINAMICS parameter list by “Data Set DDS” and are assigned an index [0..n].

More than one drive data set can be parameterized. You can switch easily between different drive configurations (control type, motor, encoder) by selecting the corresponding drive data set.

One drive object can manage up to 32 drive data sets. The number of drive data sets is configured with p0180.

Binector inputs p0820 to p0824 are used to select a drive data set. They represent the number of the drive data set (0 to 31) in binary format (where p0824 is the most significant bit).

- p0820 BI: Drive data set selection DDS, bit 0
- p0821 BI: Drive data set selection DDS, bit 1
- p0822 BI: Drive data set selection DDS, bit 2
- p0823 BI: Drive data set selection DDS, bit 3
- p0824 BI: Drive data set selection DDS, bit 4

Supplementary conditions and recommendations

- Recommendation for the number of drive data sets for a drive

The number of drive data sets for a drive should correspond to the options for switchover. The following must, therefore, apply:

$$p0180 \text{ (DDS)} \geq \max(p0120 \text{ (PDS)}, p0130 \text{ (MDS)})$$

- Maximum number of DDS for one drive object = 32 DDS

EDS: Encoder Data Set

An encoder data set contains various adjustable parameters describing the connected encoder for the purpose of configuring the drive (refer to Table 5-2).

- Adjustable parameters, e.g.:
 - Encoder interface component number (p0141)
 - Encoder component number (p0142)
 - Encoder type selection (p0400)

The parameters that are grouped together in the encoder data set are identified in the parameter list by “Data Set EDS” and are assigned an index [0..n].

A separate encoder data set is required for each encoder controlled by the Control Unit. Up to 3 encoder data sets are assigned to a drive data set via parameters p0187, p0188, and p0189.

An encoder data set can only be changed over using a DDS changeover.

Each encoder may only be assigned to one drive and within a drive must – in each drive data set – either always be encoder 1, always encoder 2 or always encoder 3.

Data sets

Using a power unit to operate, alternating, several motors, would be a typical EDS changeover application. Contactors are changed-over so that the power unit can be connected to the different motors. Each of the motors can be equipped with an encoder or can also be operated without an encoder (sensorless operation). Every encoder must be connected to its own SMx (also refer to the Chapter Motor changeover in the Function Manual).

If encoder 1 (p0187) is changed over via DDS, then an MDS must also be changed over.

One drive object can manage up to 16 encoder data sets. The number of encoder data sets configured is specified in p0140.

When a drive data set is selected, the assigned encoder data sets are also selected.

MDS: Motor Data Set

A motor data set contains various adjustable parameters describing the connected motor for the purpose of configuring the drive (refer to Table 5-2). It also contains certain visualization parameters with calculated data.

- Adjustable parameters, e.g.:
 - Motor component number (p0131)
 - Motor type selection (p0300)
 - Rated motor data (p0304 ff)
 - ...
- Visualization parameters, e.g.:
 - Calculated rated data (p0330 ff)
 - ...

The parameters that are grouped together in the motor data set are identified in the SINAMICS parameter list by “Data Set MDS” and are assigned an index [0..n].

A separate motor data set is required for each motor that is controlled by the Control Unit via a Motor Module. The motor data set is assigned to a drive data set via parameter p0186.

Motor data sets can only be switched when a DDS is switched.

The motor data set switchover is used in the following cases, for example:

- Switching over different motors
- Switching over different windings in a motor (e.g. star-delta switchover)
- Adapting the motor data

If several motors are operated alternately on a Motor Module, a matching number of drive data sets must be created. For further information about motor change-over, see the “Motor switchover” section in the Function Manual.

One drive object can manage up to 16 motor data sets. The number of motor data sets in p0130 must not exceed the number of drive data sets in p0180.

For 611U interface mode (p2038 = 1), the drive data sets are divided into groups of eight (1– 8; 8– 16;...). Within a group, the assignment to the motor data set must be the same:

p0186[0] = p0186[1] = ... = p0186[7]

p0186[8] = p0186[9] = ... = p0186[15]

p0186[16] = p0186[17] = ... = p0186[23]

p0186[24] = p0186[25] = ... = p0186[31]

If this is not the case, alarm A07514 is output.

If you need a precise representation of the data set structure of the 611U, 32 drive data sets and 4 motor data sets must be configured.

Examples for a data set assignment

Table 5-2 Example, data set assignment

DDS	Encoder 1 (p0187)	Encoder 1 (p0187)	Encoder 2 (p0188)	Encoder 3 (p0189)
DDS 0	MDS 0	EDS 0	EDS 1	EDS 2
DDS 1	MDS 0	EDS 0	EDS 3	–
DDS 2	MDS 0	EDS 0	EDS 4	EDS 5
DDS 3	MDS 1	EDS 6	–	–

Copying the command data set (vector only)

Set parameter p0809 as follows:

1. p0809[0] = number of the command data set to be copied (source)
2. p0809[1] = number of the command data to which the data is to be copied (target)
3. p0809[2] = 1

Start copying.

Copying is finished when p0809[2] = 0.

Note

In STARTER, you can copy the command data sets (Drive → Configuration → “Command data sets” tab page).

You can select the displayed command data set in the relevant STARTER screens.

Copying a drive data set

Set parameter p0819 as follows:

1. p0819[0] = Number of the drive data set to be copied (source)
2. p0819[1] = Number of the drive data set to which the data is to be copied (target)
3. p0819[2] = 1

Start copying.

Copying is finished when p0819[2] = 0.

Note

In STARTER, you can set the drive data sets via the drive configuration.

Function diagram overview (refer to the List Manual)

- 8560 Command data set (CDS)
- 8565 Drive data set (DDS)
- 8570 Encoder data set (EDS)
- 8575 Motor data set (MDS)

Overview of important parameters (refer to the List Manual)

- p0120 Power Module data set (PDS) number
- p0130 Motor data set (MDS) number
- p0140 Encoder data set (EDS) number
- p0170 Command data set (CDS) number
- p0180 Drive data sets (DDS) number
- p0809 Copy command data set (CDS)
- p0810 BI: Command data set selection CDS bit 0
- p0811 BI: Command data set selection CDS bit 1
- p0812 BI: Command data set selection CDS bit 2
- p0813 BI: Command data set selection CDS bit 3
- p0819[0...2] Copy drive data set DDS
- p0820 BI: Drive data set selection DDS, bit 0
- p0821 BI: Drive data set selection DDS, bit 1
- p0822 BI: Drive data set selection DDS, bit 2
- p0823 BI: Drive data set selection DDS, bit 3
- p0824 BI: Drive data set selection DDS, bit 4

5.3 Drive objects

A drive object is a self-contained software function with its own parameters and, if necessary, its own faults and alarms. Drive objects can be provided as standard (e.g. I/O evaluation), or you can add single (e.g. Option Board) or multiple objects (e.g. drive control).

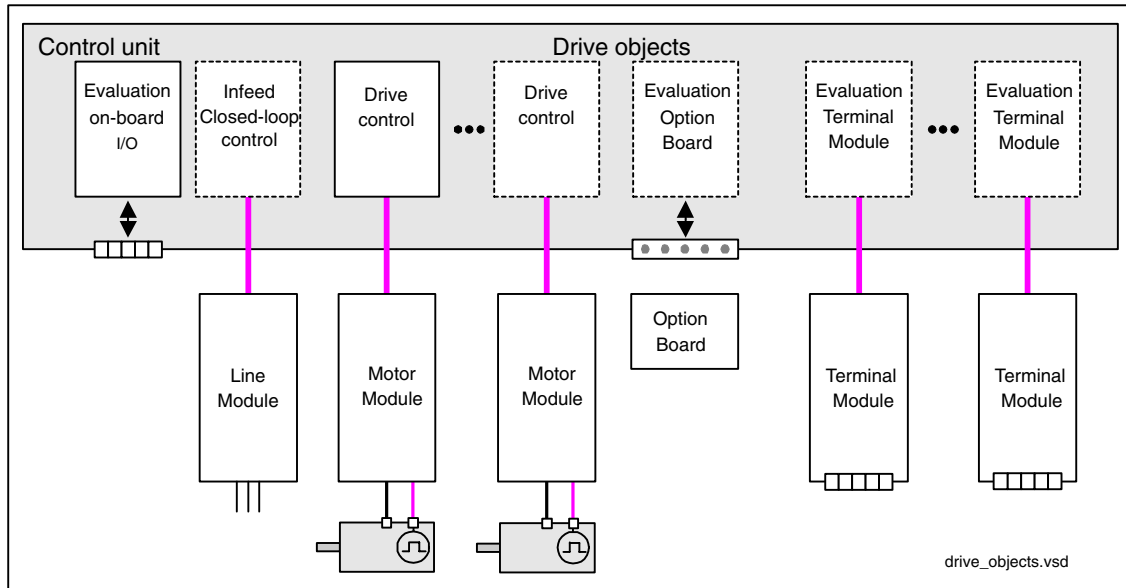


Fig. 5-4 Drive objects

Drive objects installed as standard

- Drive control

The drive control handles closed-loop control of the motor. 1 Motor Module and at least 1 motor and up to 3 sensors are assigned to the drive control.

Various types of drive control can be configured (e.g. servo control, vector control, etc.).

Several drive controls can be configured, depending on the performance of the Control Unit and the demands made on the drive control system.

- Control Unit, inputs/outputs

The I/Os on the Control Unit are evaluated within a drive object. High-speed inputs for probes are processed here in addition to bidirectional digital I/Os.

- Properties of a drive object
 - Separate parameter space
 - Separate window in STARTER
 - Separate fault/alarm system (for VECTOR, SERVO, INFEED)
 - Separate PROFIBUS telegram for process data (for VECTOR, SERVO, A_INFEED)

Optional drive objects

- Infeed: Line Module infeed control with DRIVE-CLiQ interface

If an Active Line Module with a DRIVE-CLiQ interface is used for the infeed in a drive system, open-loop/closed-loop control is implemented on the Control Unit within a corresponding drive object.
- Infeed: Line Module infeed control with DRIVE-CLiQ interface

If a Line Module without a DRIVE-CLiQ interface is used for the infeed in a drive system, the Control Unit must handle activation and evaluation of the corresponding signals (RESET, READY).
- Option Board evaluation

A further drive object is responsible for evaluating an installed Option Board. The specific method of operation depends on the type of Option Board installed.
- Terminal Module evaluation

A separate drive object handles evaluation of the respective optional Terminal Modules.

Configuring drive objects

During initial commissioning in STARTER, the drive objects processed by means of software in the Control Unit are created via configuration parameters. Various drive objects can be created within a Control Unit.

The drive objects are configurable function blocks and are used to execute specific drive functions.

If you need to configure additional drive objects or delete existing ones after initial commissioning, the drive system must be switched to configuration mode.

The parameters of a drive object cannot be accessed until the drive object has been configured and you have switched from configuration mode to parameterization mode.

Note

Each installed drive object is allocated a number between 0 and 63 during initial commissioning for unique identification.

Parameter overview (see List Manual)

Adjustable parameters

- p0101 Drive object numbers
- p0107 Drive object type
- p0108 Drive object configuration

Visualization parameters

- r0102 Number of drive objects

5.4 BICO technology: interconnecting signals

Description

Every drive contains a large number of interconnectable input and output variables and internal control variables.

BICO technology (Binector Connector Technology) allows the drive to be adapted to a wide variety of conditions.

Digital and analog signals, which can be interconnected as required by means of BICO parameters, are identified by the prefix BI, BO, CI, or CO in their parameter name. These parameters are identified accordingly in the parameter list or in the function diagrams.

Note



The STARTER parameterization and commissioning tool is recommended when you use BICO technology.

Binectors, BI: Binector Input, BO: Binector Output

A binector is a digital (binary) signal without a unit which can assume the value 0 or 1.

Binectors are subdivided into binector inputs (signal sink) and binector outputs (signal source).

Table 5-3 Binectors



Abbreviation and symbol	Name	Description
BI 	Binector input Binector input (signal sink)	Can be interconnected to a binector output as source. The number of the binector output must be entered as a parameter value.
BO 	Binector output Binector output (signal source)	Can be used as a source for a binector input.

Connectors, CI: Connector Input, CO: Connector Output

A connector is a digital signal, e.g. in the 32-bit format. It can be used to emulate words (16 bit), double words (32 bit) or analog signals. Connectors are subdivided into connector inputs (signal sink) and connector outputs (signal source).

The options for interconnecting connectors are restricted to ensure that performance is not adversely affected.

Table 5-4 Connectors

Abbreviation and symbol	Name	Description
CI 	Connector input Connector input (signal sink)	Can be interconnected to a connector output as source. The number of the connector output must be entered as a parameter value.
CO 	Connector output Connector output (signal source)	Can be used as a source for a connector input.

Interconnecting signals using BICO technology

To interconnect two signals, a BICO input parameter (signal sink) must be assigned to the required BICO output parameter (signal source).

The following information is required for connecting a binector/connector input to a binector/connector output:

- Binectors: Parameter number, bit number, and drive object ID
- Connectors with no index: Parameter number and drive object ID
- Connectors with index: Parameter number, index, and drive object ID

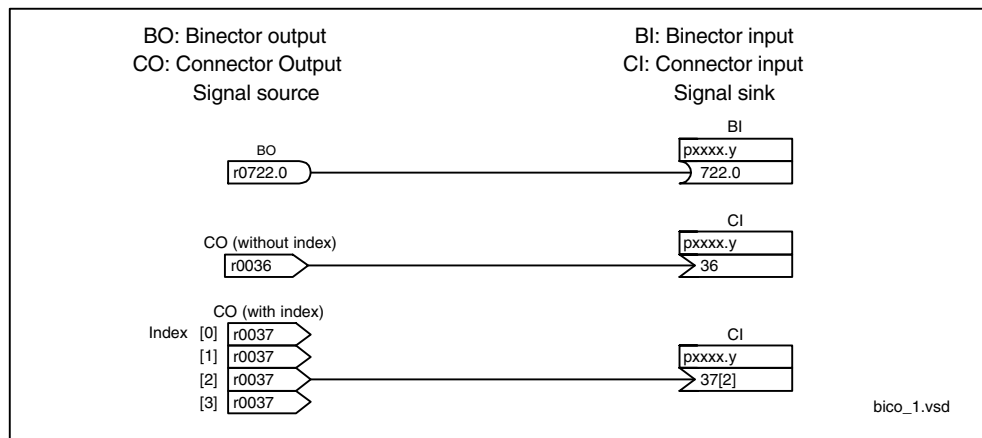


Fig. 5-5 Interconnecting signals using BICO technology

Note

A signal source (BO) can be connected to any number of signal sinks (BI).

A signal sink (BI) can only ever be connected to one signal source (BO).

The BICO parameter interconnection can be implemented in different command data sets (CDS). The different interconnections are activated by switching data sets. Interconnections across drive objects are also possible.

Internal encoding of the binector/connector output parameters

The internal codes are required for writing BICO input parameters via PROFIBUS, for example.

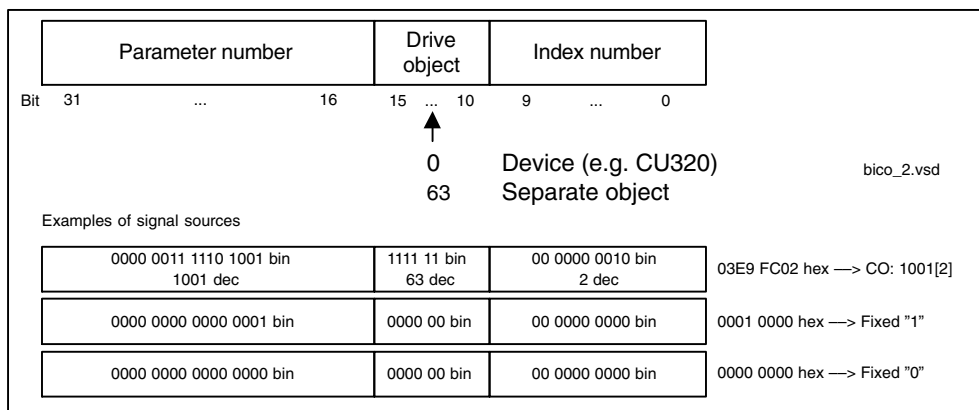


Fig. 5-6 Internal encoding of the binector/connector output parameters

Example 1: Interconnection of digital signals

Suppose you want to operate a drive via terminals DI 0 and DI 1 on the Control Unit using jog 1 and jog 2.

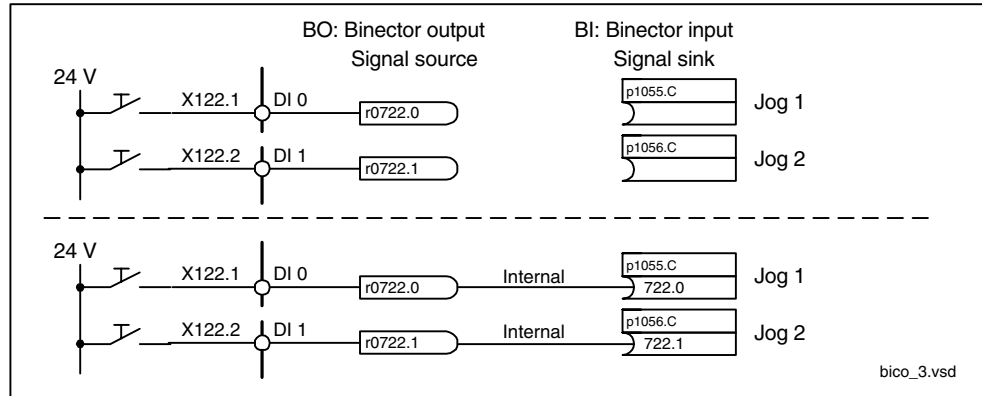


Fig. 5-7 Interconnection of digital signals (example)

Example 2: Connection of OC/OFF3 to several drives

The OFF3 signal is to be connected to two drives via terminal DI 2 on the Control Unit.

Each drive has a binector input 1. OFF3 and 2. OFF3. The two signals are processed via an AND gate to STW1.2 (OFF3).

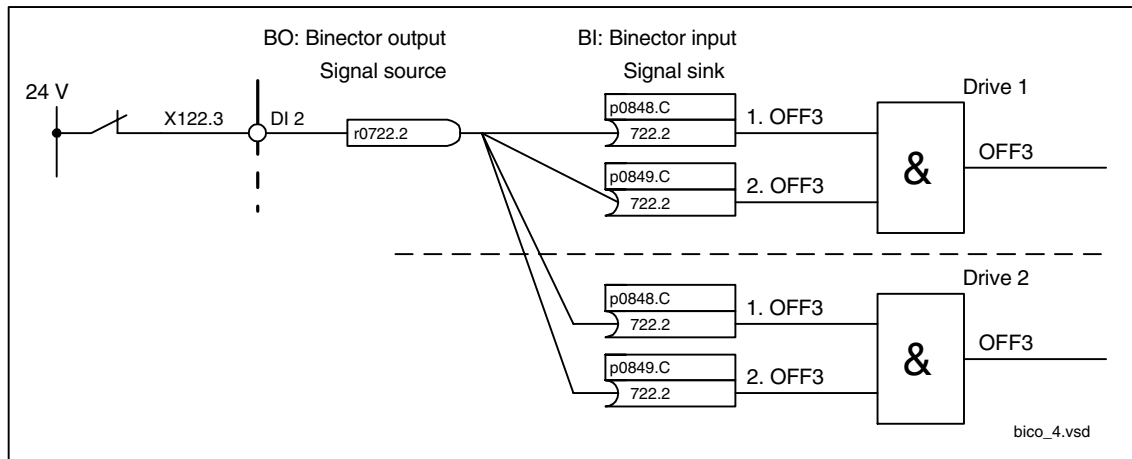


Fig. 5-8 Connection of OFF3 to several drives (example)

BICO interconnections to other drives

The following parameters are available for BICO interconnections to other drives:

- r9490 Number of BICO interconnections to other drives
- r9491[0...15] BI/CI of BICO interconnections to other drives
- r9492[0...15] BO/CO of BICO interconnections to other drives
- p9493[0...15] Reset BICO interconnections to other drives

Copying drives

When a drive is copied, the interconnection is copied with it.

Binector-connector converters and connector-binector converters

Binector-connector converter

- Several digital signals are converted to a 32-bit integer double word or to a 16-bit integer word.
- p2080[0...15] BI: PROFIBUS PZD send bit-serial

Connector-binector converter

- A 32-bit integer double word or a 16-bit integer word is converted to individual digital signals.
- p2099[0...1] CI: PROFIBUS PZD selection receive bit-serial

Fixed values for interconnection using BICO technology

The following connector outputs are available for interconnecting any fixed value settings:

- p2900[0...n] CO: Fixed value_%%_1
- p2901[0...n] CO: Fixed value_%%_2
- p2930[0...n] CO: Fixed Value_M_1

Example:

These parameters can be used to interconnect the scaling factor for the main set-point or to interconnect an additional torque.

Signals for the analog outputs

Table 5-5 List of signals for analog outputs

Signal	Parameter	Units	Normalization (100 % = ...)
Speed setpoint before the setpoint filter	r0060	RPM	p2000
Speed actual value motor encoder	r0061	RPM	p2000
Actual speed	r0063	RPM	p2000
Drive output frequency	r0066	Hz	Reference frequency
Absolute current actual value	r0068	Aeff	p2002
Actual DC link voltage value	r0070	V	p2001
Total torque setpoint	r0079	Nm	p2003
Actual active power	r0082	kW	r2004
Control deviation	r0064	RPM	p2000
Modulation depth	r0074	%	Reference control factor
Current setpoint, torque-generating	r0077	A	p2002
Current actual value, torque-generating	r0078	A	p2002
Flux setpoint	r0083	%	Reference flux
Flux actual value	r0084	%	Reference flux
Speed controller PI torque output	r1480	Nm	p2003
Speed controller I torque output	r1482	Nm	p2003

Scaling for vector object

Table 5-6 Scaling for vector object

Quantity	Scaling parameter	Default at initial commissioning
Reference speed	100 % = p2000	p2000 = Maximum speed (p1082)
Reference voltage	100 % = p2001	p2001 = 1000 V
Reference current	100 % = p2002	p2002 = Current limit (p0640)
Reference torque	100 % = p2003	p2003 = 2 * rated motor torque (p0333)
Reference power	100 % = r2004	r2004 = p2003 * p2000 * $2\pi / 60$
Reference frequency	100 % = p2000/60	–
Reference control factor	100 % = Maximum output voltage without overload	–
Reference flux	100 % = Rated motor flux	–
Reference temperature	100 % = 100°C	–
Reference electrical angle	100 % = 90°	–

Scaling for servo object

Table 5-7 Scaling for servo object

Quantity	Scaling parameter	Default at initial commissioning
Reference speed	100 % = p2000	Induction motor p2000 = maximum motor speed (p0322) Synchronous motor p2000 = rated motor speed (p0311)
Reference voltage	100 % = p2001	p2001 = 1000 V
Reference current	100 % = p2002	p2002 = Motor limit current (p0338); when p0338 = "0", 2 * rated motor current (p0305)
Reference torque	100 % = p2003	p2003 = p0338 * p0334; when "0", 2 * rated motor torque (p0333)
Reference power	100 % = r2004	r2004 = p2003 * p2000 * $\pi / 30$
Reference frequency	100 % = p2000/60	–
Reference control factor	100 % = Maximum output voltage without overload	–
Reference flux	100 % = Rated motor flux	–
Reference temperature	100 % = 100°C	–
Reference electrical angle	100 % = 90°	–

Scaling for object A_Inf

Table 5-8 Scaling for object A_Inf

Quantity	Scaling parameter	Default at initial commissioning
Reference frequency	100 % = p2000	p2000 = p0211
Reference voltage	100 % = p2001	p2001 = r0206/r0207
Reference current	100 % = p2002	p2002 = p0207
Reference power	100 % = r2004	r2004 = p0206
Reference control factor	100 % = Maximum output voltage without overload	–
Reference temperature	100 % = 100°C	–
Reference electrical angle	100 % = 90°	–

Scaling for object B_Inf

Table 5-9 Scaling for object B_Inf

Quantity	Scaling parameter	Default at initial commissioning
Reference frequency	100 % = p2000	p2000 = 50
Reference voltage	100 % = p2001	p2001 = r0206/r0207
Reference current	100 % = p2002	p2002 = p0207
Reference power	100 % = r2004	r2004 = p0206
Reference temperature	100 % = 100°C	–
Reference electrical angle	100 % = 90°	–



Availability of SW Functions

Table A-1 New functions **FW 2.2**

No.	SW function	Available since FW	Servo	Vector	HW component
1	Technology controller	2.2	X	X	
2	2 command data sets	2.2	–	X	
3	Extended brake control	2.2	X	X	
4	Automatic restart for Vector and Smart Line Modules 5/10 kW	2.2	–	X	
5	The ability to mix servo and vector V/f modes on one CU	2.2	par- tially	par- tially	
6	Regulated $V_{DC \text{ link}}$ up to 480V input voltage can be parameterized for active line modules	2.2	X	X	
7	Smart Mode for Active Line Modules	2.2	X	X	
8	Extended setpoint channel can be activated	2.2	X	–	
9	Evaluation, linear measuring systems	2.2	X	–	
10	Synchronous motors 1FT6/1FK6/1FK7 with DRIVE-CLiQ resolver	2.2	X	–	

Table A-2 New functions **FW 2.3**

No.	SW function	Available since FW	Servo	Vector	HW component
1	Motor data set changeover (8 motor data sets)	2.3	X	X	
2	Buffer for faults/alarms	2.3	X	X	
3	Rotor/pole position identification	2.3	X	X	
4	Bootling with partial topology, parking axis/encoder, de-activating/activating components	2.3	X	X	
5	Friction characteristic with 10 points along the characteristic, automatic characteristic plot	2.3	X	X	
6	Utilization display	2.3	X	X	
7	Evaluation of distance-coded zero marks for higher-level controls	2.3	X	–	

Table A-2 New functions **FW 2.3**, continued

No.	SW function	Available since FW	Servo	Vector	HW component
8	Hanging/suspended axes/electronic weight equalization for higher-level controls	2.3	X	–	
9	SIMATIC S7 OPs can be directly coupled	2.3	X	X	
10	PROFIBUS NAMUR standard telegrams	2.3	–	X	
11	Mixed operation of various infeed types	2.3	X	X	For chassis drive units
12	Parallel circuit configuration	2.3	–	X	For chassis drive units
13	Edge modulation	2.3	X	X	For chassis drive units
14	Servo control type	2.3	X	–	also chassis drive units
15	Terminal Module TM15 (DI/DO functionality)	2.3	X	X	
16	1FN1, 1FN3 linear motors	2.3	X	–	
17	1FW6 torque motors	2.3	X	–	
18	1FE1 synchronous built-in motors	2.3	X	–	
19	2SP1 synchronous spindles	2.3	X	–	
20	1FU8 SIMOSYN Motors	2.3	X	–	
21	1FS6 explosion-protected motors	2.3	X	–	
22	SME20/25 external sensor modules for incremental and absolute encoder evaluation	2.3	X	X	

Table A-3 New functions **FW 2.4**

No.	SW function	Available since FW	Servo	Vector	HW component
1	SINAMICS S120 functionality for AC DRIVE (CU310DP/PN)	2.4	X	X	
2	Basic positioning	2.4	X	X	
3	Encoder data changeover (3 EDS encoder data sets)	2.4	X	X	
4	2 command data sets (CDS)	2.4	X	X	
5	Units changeover SI / US / %	2.4	X	X	
6	Motor data identification servo	2.4	X		
7	Increased torque accuracy for synchronous motors (kt estimator)	2.4	X		
8	Hub functionality (hot plugging, distributed encoder, star structure via DMC20)	2.4	X	X	
9	Basic Operator Panel BOP20	2.4	X	X	
10	SSI encoder (SMC30)	2.4	X	X	6SL3055-0AA00-5CA1

Table A-3 New functions **FW 2.4**, continued

No.	SW function	Available since FW	Servo	Vector	HW component
11	Pulse encoder emulation TM41	2.4	X	X	
12	Automatic restart with Active Line Module	2.4	X	X	
13	PROFIBUS extensions: Peer-to-peer data transfer, Y link, telegram 1 also for servo, telegrams 2, 3, 4 – also vector	2.4	par- tially	par- tially	
14	Safety Integrated Stop category 1 (SS1) with safety-related time	2.4	X	X	
15	Measuring gearbox	2.4	X	X	
16	Setting the pulse frequency grid in fine steps	2.4	X	X	
17	Controller clock cycles that can be set	2.4	X	X	
18	Possibility of mixing clock cycles on a DRIVE-CLiQ line	2.4	X	X	
19	Clockwise/counter clockwise bit (the same as changing the rotating field)	2.4	X	X	
20	Sensor Module for 1FN, 1FW6 with protective separation (SME120/125)	2.4	X	–	
21	Real time stamps for alarms	2.4	X	X	CU320, 6SL3040--0AA1 and Version C or higher
22	Sensorless closed-loop speed control for torque motors	2.4	–	X	
23	Separately-excited synchronous motors with encoder	2.4	–	X	
24	Technological pump functions	2.4	–	X	
25	Drive converter/drive converter, drive converter/line supply (bypass) synchronizing	2.4	X	X	For chassis drive units
26	Voltage Sensing Module (VSM) for Active Line Module	2.4			also for booksize drive units
27	Armature short-circuit braking, synchronous motors	2.4	X	–	
28	CANopen extensions (vector, free process data access, profile DS301)	2.4	X	X	
29	PROFINET IO communication with Option Module CBE20	2.4	X	X	
30	New hardware components are supported (AC DRIVE, SME120/125, BOP20, DMC20, TM41)	2.4	X	X	

Table A-3 New functions **FW 2.4**, continued

No.	SW function	Available since FW	Servo	Vector	HW component
31	Position tracking for torque motors (not for EPOS)	2.4	X	X	CU320, 6SL3040-- 0AA1 and Version C or higher
32	1FW3 torque motors	2.4	X	–	



B

List of Abbreviations

Abbreviation	German	English
A		
A ...	Warnung	Alarm
AC	Wechselstrom	Alternating Current
ADC	Analog-Digital-Konverter	Analog Digital Converter
AI	Analogeingang	Analog Input
ALM	Active Line Module	Active Line Module
AO	Analogausgang	Analog Output
AOP	Advanced Operator Panel	Advanced Operator Panel
APC	Advanced Positioning Control	Advanced Positioning Control
ASC	Ankerkurzschluss	Armature Short-Circuit
ASCII	Amerikanische Code-Norm für den Informationsaustausch	American Standard Code for Information Interchange
ASM	Asynchronmotor	Induction Motor
B		
BB	Betriebsbedingung	Operating condition
BERO	Firmenname für einen Näherungsschalter	Tradename for a type of proximity switch
BI	Binektoreingang	Binector Input
BIA	Berufsgenossenschaftliches Institut für Arbeitssicherheit	Berufsgenossenschaftliches Institut für Arbeitssicherheit (German Institute for Occupational Safety)
BICO	Binektor-Konnektor-Technologie	Binector Connector Technology
BLM	Basic Line Module	Basic Line Module
BOP	Basic Operator Panel	Basic Operator Panel
C		
C	Kapazität	Capacitance
C...	Safety-Meldung	Safety message
CAN	Seriellles Bussystem	Controller Area Network
CBC	Kommunikationsbaugruppe CAN	Communication Board CAN
CD	Compact Disc	Compact Disc
CDS	Befehlsdatensatz	Command Data Set
CI	Konnectoreingang	Connector Input

Abbreviation	German	English
CNC	Computerunterstützte numerische Steuerung	Computer Numerical Control
CO	Konnektorausgang	Connector Output
CO/BO	Konnektor-/Binektorausgang	Connector Output/Binector Output
COB-ID	CAN Object-Identification	CAN Object-Identification
COM	Mittelkontakt eines Wechselkontaktes	Common contact of a change-over relay
CP	Kommunikationsprozessor	Communications Processor
CPU	Zentralbaugruppe	Central Processing Unit
CRC	Checksummenprüfung	Cyclic Redundancy Check
CSM	Control Supply Module	Control Supply Module
CU	Control Unit	Control Unit
D		
DAC	Digital-Analog-Konverter	Digital Analog Converter
DC	Gleichstrom	Direct Current
DCN	Gleichstrom negativ	Direct current negative
DCP	Gleichstrom positiv	Direct current positive
DDS	Antriebsdatensatz	Drive Data Set
DI	Digitaleingang	Digital Input
DI/DO	Digitaleingang/-ausgang bidirektional	Bidirectional Digital Input/Output
DMC	DRIVE-CLiQ Module Cabinet (Hub)	DRIVE-CLiQ Module Cabinet (Hub)
DO	Digitalausgang	Digital Output
DO	Antriebsobjekt	Drive Object
DPRAM	Speicher mit beidseitigem Zugriff	Dual Ported Random Access Memory
DRAM	Dynamischer Speicher	Dynamic Random Access Memory
DRIVE-CLiQ	Drive Component Link with IQ	Drive Component Link with IQ
DSC	Dynamic Servo Control	Dynamic Servo Control
E		
EDS	Geberdatensatz	Encoder Data Set
EGB	Elektrostatisch gefährdete Baugruppen	Electrostatic Sensitive Devices (ESD)
ELP	Erdschlussüberwachung	Earth Leakage Protection
EMK	Elektromagnetische Kraft	Electromagnetic Force (EMF)
EMV	Elektromagnetische Verträglichkeit	Electromagnetic Compatibility (EMC)
EN	Europäische Norm	European Standard
EnDat	Geber-Schnittstelle	Encoder-Data-Interface
EP	Impulsfreigabe	Enable Pulses
EPOS	Einfachpositionierer	Basic positioner
ES	Engineering System	Engineering System
ESB	Ersatzschaltbild	Equivalent circuit diagramm

Abbreviation	German	English
ESR	Erweitertes Stillsetzen und Rückziehen	Extended Stop and Retract
F		
F ...	Störung	Fault
FAQ	Häufig gestellte Fragen	Frequently Asked Questions
FCC	Function Control Chart	Function Control Chart
FCC	Flussstromregelung	Flux Current Control
FEM	Fremderregter Synchronmotor	Separately excited synchronous motor
FEPROM	Schreib- und Lesespeicher nichtflüchtig	Flash-EPROM
FG	Funktionsgenerator	Function Generator
FI	Fehlerstrom-Schutzschalter	Earth Leakage Circuit-Breaker (ELCB)
FP	Funktionsplan	Function diagram
FW	Firmware	Firmware
G		
GB	Gigabyte	Gigabyte
GC	Global-Control-Telegramm (Broadcast-Telegramm)	Global Control Telegram (Broadcast Telegram)
GSD	Gerätstammdatei: beschreibt die Merkmale eines PROFIBUS-Slaves	Device master file: describes the features of a PROFIBUS slave
GSV	Gate Supply Voltage	Gate Supply Voltage
H		
HF	Hochfrequenz	High frequency
HFD	Hochfrequenzdrossel	High frequency reactor
HLG	Hochlaufgeber	Ramp-function generator
HMI	Mensch-Maschine-Schnittstelle	Human Machine Interface
HTL	Logik mit hoher Störschwelle	High-Threshold Logic
HW	Hardware	Hardware
I		
i. V.	In Vorbereitung: diese Eigenschaft steht zur Zeit nicht zur Verfügung	In preparation: this feature is currently not available
IBN	Inbetriebnahme	Commissioning
I/O	Eingang/Ausgang	Input/Output
ID	Identifizierung	Identifier
IEC	Internationale Norm in der Elektrotechnik	International Electrotechnical Commission
IGBT	Bipolartransistor mit isolierter Steuerelektrode	Insulated Gate Bipolar Transistor
IL	Impulslöschung	Pulse suppression
IT	Drehstromversorgungsnetz ungeerdet	Three-phase supply network ungrounded
IVP	Interner Spannungsschutz	Internal Voltage Protection

Abbreviation	German	English
J		
JOG	Tippen	Jogging
K		
KDV	Kreuzweiser Datenvergleich	Data cross-checking
KIP	Kinetische Pufferung	Kinetic buffering
Kp	Proportionalverstärkung	Proportional gain
KTY	Spezieller Temperatursensor	Special temperature sensor
L		
L	Induktivität	Inductance
LED	Leuchtdiode	Light Emitting Diode
LIN	Linearmotor	Linear motor
LR	Lageregler	Position controller
LSB	Niederwertigstes Bit	Least Significant Bit
LSS	Netzschalter	Line Side Switch
LU	Längeneinheit	Length Unit
M		
M	Masse	Reference potential, zero potential
MB	Megabyte	Megabyte
MCC	Motion Control Chart	Motion Control Chart
MDS	Motordatensatz	Motor Data Set
MLFB	Maschinenlesbare Fabrikatebezeichnung	Machine-readable product designation
MMC	Mensch Maschine Kommunikation	Man-Machine Communication
MSB	Höchstwertigstes Bit	Most Significant Bit
MSCY_C1	Zyklische Kommunikation zwischen Master (Klasse 1) und Slave	Master Slave Cycle Class 1
MT	Messtaster	Measuring probe
N		
N. C.	Nicht angeschlossen	Not connected
N...	Keine Meldung oder Interne Meldung	No Report
NAMUR	Normenarbeitsgemeinschaft für Mess- und Regeltechnik in der chemischen Industrie	Standardization association for measurement and control in chemical industries
NC	Öffner	Normally Closed (contact)
NC	Numerische Steuerung	Numerical Control
NEMA	Normengremium in USA (United States of America)	National Electrical Manufacturers Association
NM	Nullmarke	Zero Mark
NO	Schließer	Normally Open (contact)

Abbreviation	German	English
O		
OA	Open Architecture	Open Architecture
OEM	Original Equipment Manufacturer	Original Equipment Manufacturer
OLP	Busstecker für Lichtleiter	Optical Link Plug
OMI	Option Module Interface	Option Module Interface
P		
p ...	Einstellparameter	Adjustable parameter
PcCtrl	Steuerungshoheit	Master Control
PDS	Leistungsteildatensatz	Power unit Data Set
PE	Schutzerde	Protective Earth
PELV	Schutzkleinspannung	Protective Extra Low Voltage
PEM	Permanenterregter Synchronmotor	Permanent-magnet synchronous motor
PG	Programmiergerät	Programming terminal
PI	Proportional Integral	Proportional Integral
PID	Proportional Integral Differential	Proportional Integral Differential
PLC	Speicherprogrammierbare Steuerung (SPS)	Programmable Logical Controller
PLL	Baustein zur Synchronisierung	Phase Locked Loop
PNO	PROFIBUS Nutzerorganisation	PROFIBUS user organisation
PPI	Punkt zu Punkt Schnittstelle	Point to Point Interface
PRBS	Weißes Rauschen	Pseudo Random Binary Signal
PROFIBUS	Serieller Datenbus	Process Field Bus
PS	Stromversorgung	Power Supply
PSA	Power Stack Adapter	Power Stack Adapter
PTC	Positiver Temperaturkoeffizient	Positive Temperature Coefficient
PTP	Punkt zu Punkt	Point To Point
PWM	Pulsweitenmodulation	Pulse Width Modulation
PZD	PROFIBUS Prozessdaten	PROFIBUS Process data
Q		
R		
r ...	Beobachtungsparameter (nur lesbar)	Display parameter (read only)
RAM	Speicher zum Lesen und Schreiben	Random Access Memory
RCCB	Fehlerstrom-Schutzschalter	Residual Current Circuit Breaker
RCD	Fehlerstrom-Schutzschalter	Residual Current Device
RJ45	Norm. Beschreibt eine 8-polige Steckverbindung mit Twisted-Pair Ethernet.	Standard. Describes an 8-pole plug connector with twisted pair Ethernet.
RKA	Rückkühlanlage	Recooling system

Abbreviation	German	English
RO	Nur lesbar	Read Only
RPDO	Receive Process Data Object	Receive Process Data Object
RS232	Serielle Schnittstelle	Serial Interface
RS485	Norm. Beschreibt die Physik einer digitalen seriellen Schnittstelle.	Standard. Describes the physical characteristics of a digital serial interface.
RTC	Echtzeituhr	Real Time Clock
S		
S1	Dauerbetrieb	Continuous operation
S3	Aussetzbetrieb	Periodic duty
SBC	Sichere Bremsenansteuerung	Safe Brake Control
SBH	Sicherer Betriebs halt	Safe operating stop
SBR	Sichere Bremsrampe	Safe braking ramp
SBT	Sicherer Bremsentest	Safe Brake Test
SCA	Sichere Nocke	Safe Cam
SDI	Sichere Richtung	Safe Direction
SE	Sichere Software-Endschalter	Safe software limit switch
SG	Sicher reduzierte Geschwindigkeit	Safe reduced speed
SGA	Sicherheitsgerichteter Ausgang	Safety-related output
SGE	Sicherheitsgerichteter Eingang	Safety-related input
SH	Sicherer Halt	Safe Standstill
SI	Safety Integrated	Safety Integrated
SIL	Sicherheitsintegritätsgrad	Safety Integrity Level
SLI	Sicheres Schrittmaß	Safety Limited Increment
SLM	Smart Line Module	Smart Line Module
SLP	Sichere Endlage	Safely Limited Position
SLS	Sicher reduzierte Geschwindigkeit	Safety Limited Speed
SLVC	Geberlose Vektorregelung	Sensorless Vector Control
SM	Sensor Module	Sensor Module
SMC	Sensor Module Cabinet	Sensor Module Cabinet
SME	Sensor Module External	Sensor Module External
SN	Sichere Software-Nocken	Safe software cam
SOS	Sicherer Betriebs halt	Safe Operational
SPC	Sollwertkanal	Setpoint Channel
SPS	Speicherprogrammierbare Steuerung	Programmable Logic Controller (PLC)
SS1	Safe Stop 1	Safe Stop 1
SS2	Safe Stop 2	Safe Stop 2
SSI	Synchron Serielle Schnittstelle	Synchronous Serial Interface
SSM	Sichere Geschwindigkeitsanzeige n< nx	Safe Speed Monitoring n< nx

Abbreviation	German	English
SSR	Sichere Bremsrampe	Safe Stop Ramp
STO	Sicherer Halt	Safe Torque Off
STW	PROFIBUS Steuerwort	PROFIBUS control word
T		
TB	Terminal Board	Terminal Board
TIA	Totally Integrated Automation	Totally Integrated Automation
TM	Terminal Module	Terminal Module
TN	Drehstromversorgungsnetz geerdet	Grounded three-phase supply network
Tn	Nachstellzeit	Integral time
TPDO	Transmit Process Data Object	Transmit Process Data Object
TT	Drehstromversorgungsnetz geerdet	Grounded three-phase supply network
TTL	Transistor-Transistor-Logik	Transistor-Transistor-Logic
U		
UL	Underwriters Laboratories Inc.	Underwriters Laboratories Inc.
USV	Unterbrechungsfreie Stromversorgung	Uninterruptible power supply
V		
VC	Vektorregelung	Vector Control
Vdc	Zwischenkreisspannung	DC link voltage
VdcN	Teilzwischenkreisspannung negativ	Partial DC link voltage negative
VdcP	Teilzwischenkreisspannung positiv	Partial DC link voltage positive
VDE	Verband Deutscher Elektrotechniker	Association of German Electrical Engineers
VDI	Verein Deutscher Ingenieure	Association of German Engineers
Vpp	Volt Spitze zu Spitze	Volt peak to peak
VSM	Voltage Sensing Module	Voltage Sensing Module
W		
WEA	Wiedereinschaltautomatik	Automatic restart
WZM	Werkzeugmaschine	Machine tool
X		
XML	Erweiterbare Auszeichnungssprache (Standardsprache für Web-Publishing und Dokumentenmanagement)	Extensible Markup Language
Y		
Z		
ZK	Zwischenkreis	DC link
ZSW	PROFIBUS Zustandswort	PROFIBUS statusword



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/D11/	SINAMICS G130 Drive Converter Chassis Units, SINAMICS G150 Drive Converter Cabinet Units Order No.: E86060-K5511-A101-A3	12.2005 Edition
/D21.1/	SINAMICS S120 Vector Control Drive System Order number: E86060-K5521-A111-A2	06.2005 Edition
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- /CA01/ Automation and Drives' Offline Mall**
CD-ROM
Order number: E86060-D4001-A100-C4 10.2005 Edition
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<http://www.siemens.com/automation/mall>

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- /CD2/ SINAMICS**
The SINAMICS System
Order No.: 6SL3097-2CA00-0YG3 05.2006 Edition

User Documentation

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Operating Instructions
Order number: On request 03.2006 Edition
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Order number: On request 03.2006 Edition
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/GH6/	SINAMICS S120 Equipment Manual AC DRIVE Order No.: 6SL3097-2AL00-0BP0	03.2006 Edition
/GS1/	SINAMICS S120 Getting Started Order No.: 6SL3097-2AG00-0BP2	03.2006 Edition
/IH1/	SINAMICS S120 Installation and Startup Manual Order No.: 6SL3097-2AF00-0BP3	03.2006 Edition
/FH1/	SINAMICS S120 Function Manual Order number: 6SL3097-2AB00-0BP2	03.2006 Edition
/IH2/	SINAMICS S120 Commissioning Manual CANopen Order No.: 6SL3097-2AA00-0BP2	03.2006 Edition
/LH1/	SINAMICS S List Manual Order No.: 6SL3097-2AP00-0BP4	03.2006 Edition
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Hüthig; Manfred Popp, 2nd Edition
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/P3/ Distributed Layouts using PROFIBUS-DP
Architecture and Fundamentals, Configuration and Use of PROFIBUS-DP with
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SIEMENS; Publicis MCD Verlag; Josef Weigmann, Gerhard Kilian
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/P5/ PROFIBUS Profile PROFIdrive Profile Drive Technology
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/IKPI/ SIMATIC NET, Industrial Communication and Field Equipment
Catalog
Order number: E86060-K6710-A101-B4 2005 Edition

/PDP/ PROFIBUS Installation Guidelines
Installation Guideline for PROFIBUS-FMS/DP
Installation and wiring recommendation for RS 485 Transmission
Order No.: 2.111 (German)
2.112 (English) Version 1.0

Documentation for Safety Equipment

Note

For more information about technical documentation for Safety Integrated, visit the following address:

<http://www.siemens.de/safety>

The following list contains some of the safety-related documentation available.

/LV1/	Low-Voltage Switchgear Catalog Order number: E86060-K1002-P101-A5	2006 Edition
/MRL/	Directive 98/37/EEC of the European Parliament and Council Machine directive Bundesanzeiger-Verlags GmbH	06/22/1998 Edition
/SISH/	Safety Integrated System Manual Order No.: 6ZB5000-0AA01-0BA1	5th edition
/SICD/	Safety Integrated CD-ROM Order No.: E20001-D10-M103-X-7400	09.2004 Edition



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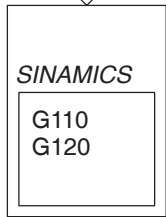
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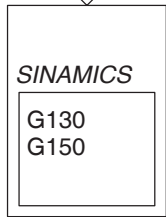
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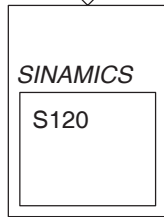
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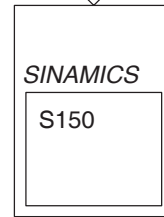
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Converter Chassis Units
0.12 – 3 kW



D11
Converter Chassis Units
Converter Cabinet Units

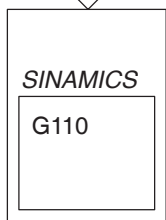


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Chassis Units

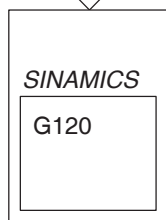


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Vector Control Cabinet Units
75 – 1200 kW

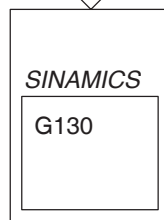
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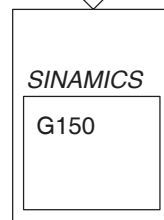
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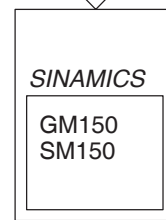
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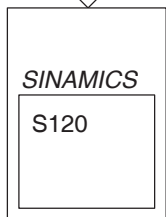


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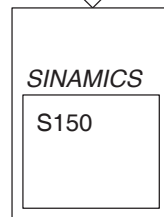


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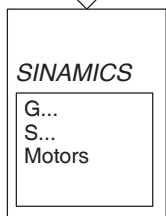


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- Equipment Manual for Control Units and Additional System Components
- Equipment Manual for Booksize Power Modules
- Equipment Manual Booksize Cold-Plate Power Sections
- Chassis Power Sections
- Equipment Manual AC DRIVE
- Commissioning Manual – Commissioning Manual CANopen
- Function Manual – Function Manual Free Function Blocks
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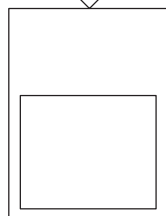


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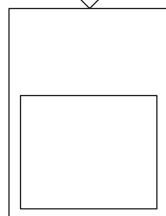
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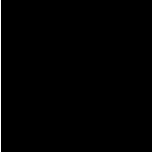
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Configuration Manual
Motors



EMC
Installation Guideline



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